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Teckenberg-Jansson, Pia

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ORIGINAL RESEARCH ARTICLE

Effects of live music therapy on heart rate variability and self-reported stress and anxiety among hospitalized pregnant women: A randomized controlled trial

Pia Teckenberg-Jansson^a, Siiri Turunen^b, Tarja Pölkki^c, Minna-Johanna Lauri-Haikala^b, Jari Lipsanen^b, Andreas Henelius^{d,e}, Ansa Aitokallio-Tallberg^f, Satu Pakarinen^d, Marianne Leinikka^d and Minna Huotilainen^b

^aSävelvoima-Tonkraft, Västerskog, Finland; ^bCICERO Learning Network, Faculty of Educational Sciences and Cognitive Brain Research Unit, Department of Psychology and Logopedics, Faculty of Medicine, University of Helsinki, Helsinki, Finland; ^cDepartment of Children and Women, Oulu University Hospital, Oulu, Finland; ^dFinnish Institute of Occupational Health, Helsinki, Finland; ^eDepartment of Computer Science, University of Helsinki, Helsinki, Finland; ^fDepartment of Obstetrics and Gynecology, Helsinki University Hospital, University of Helsinki, Helsinki, Finland

ABSTRACT

Introduction: This study aims to evaluate the effects of live music therapy on heart rate variability (HRV) and self-reported stress and anxiety among hospitalized women with high-risk pregnancies. A total of 102 women at an antenatal ward due to pregnancy-related complications participated in a randomized controlled trial.

Methods: The participants were randomly assigned to a music therapy group ($N = 52$) or control group ($N = 50$). The women in the music therapy group received live music therapy on three consecutive days, for half an hour at a time. The participants belonging to the control group were instructed to rest for equally long time periods. The physiologic stress of the participants was assessed using HRV measures. The participants also rated their perceived stress and anxiety. The physiologic stress of the participants was assessed using 12 HRV measures.

Results: The SD2 measure of HRV increased significantly more in the music therapy group than in the control group during the therapy sessions. Moreover, the low frequency (LF) HRV measure decreased during the three-day therapy period. The self-reported stress was not significantly altered after the intervention. For women with high initial self-reported anxiety in both groups, their anxiety was significantly reduced during the three-day period.

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KEYWORDS Prenatal stress; prenatal anxiety; live music therapy; pregnancy complications; heart rate variability (HRV)

Introduction

Research over the last three decades has established that women experiencing high stress and anxiety during pregnancy are at risk of preterm birth and miscarriage

CONTACT Pia Teckenberg-Jansson ✉ pia.teckenberg@kolumbus.fi Sävelvoima-Tonkraft, Stuvunäsvägen 11, 01120 Västerskog, Finland; Minna Huotilainen ✉ minna.huotilainen@helsinki.fi CICERO Learning Network, Faculty of Educational Sciences, P.O. Box 9, 00014 University of Helsinki, Finland.

Supplementary data for this article can be accessed [here](#).

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(Dole et al., 2003; Douglas, 2010; Lobel et al., 2008; Mulder et al., 2002). Preterm born children with low birth weight may suffer from long-term health problems such as neurodevelopmental disorders (Soleimani, Zaheri, & Abdi, 2014) and later depression (Räikkönen et al., 2008). High antenatal maternal stress and anxiety is related to regulation problems at the cognitive, behavioral, and emotional levels. Further, stress and anxiety may interfere with fetal development, even increasing the risk for severe lifelong diseases (Douglas, 2010; Van Den Bergh, Mulder, Mennes, & Glover, 2005). Maternal stress has also been shown to have a causal connection to fetal stress as reduced fetal HRV (DiPietro, Hodgson, Costigan, Hilton, & Johnson, 1996).

Pregnancy-specific stress is indicated to be a more powerful contributor to birth outcomes than general stress (Lobel et al., 2008), and having a high-risk pregnancy increases the impact of stress (Geller, 2004). Notably, hospitalized pregnant women treated with bed rest have a considerably higher risk of experiencing anxiety and stress (Maloni & Park, 2005). Physical and emotional changes during pregnancy, in addition to the concerns about parenting, changing family relationships, labor, and the child's health, may produce stress for pregnant women (Chang, Chen, & Huang, 2008; Lobel et al., 2008). Prenatal stress and anxiety should be seriously considered in health care due to its consequences for fetal development and well-being (Dennis, Falah-Hassani, & Shiri, 2017; Graignic-Philippe & Tordjman, 2009; Van Den Bergh et al., 2005). Consequently, there is an essential need for stress relief during pregnancy.

Non-pharmacological interventions have been developed specifically for the care of pregnant women, since pharmacological treatments may pose serious risks for both the mother and fetus (Calderon-Margalit, Qiu, Ornoy, Siscovick, & Williams, 2009; Chang et al., 2008). Bed rest is often prescribed for women with high-risk pregnancies but may result in adverse physical and psychological consequences such as fatigue, backache, and depression, which may continue after the child is born (Maloni & Park, 2005). Maternal relaxation may be beneficial for the fetus and lead to decreased fetal heart rate, increased fetal HRV and suppression of fetal motor activity (DiPietro, Costigan, Nelson, Gurewitsch, & Laudenslager, 2008). Significant prolongation of pregnancy can be achieved through a relaxation training program for hospitalized pregnant women (Chuang et al., 2012a). Beneficial effects of relaxation on reducing self-reported anxiety and stress in pregnant women have also been found (Bastani, Hidarnia, Kazemnejad, Vafaei, & Kashanian, 2005).

Music is widely known to enhance well-being, reduce stress and distract patients from unpleasant symptoms by exerting direct physiological effects through the autonomic nervous system (Kemper & Danhauer, 2005). Listening to relaxing music lowers perceived stress levels, as indicated by reduced cortisol levels, lowered heart rate, and lowered mean arterial pressure (Burrai, Hasan, Fancourt, Luppi, & DiSomma, 2016; Lai & Li, 2011). Bieligmeyer (2015) studied the effects of the Tao sound-bed (Benedek) on oncology patients and found significant changes of inner balance, vitality, and vigilance. Gilboa (2014) studied the uterine auditory environment and its effects on the fetus. Mothers listening to music during pregnancy experienced lower levels of psychosocial stress; music particularly alleviated the stress related to future baby care, changing family relationships, and the maternal role identification (Chang, Yu, Chen, & Chen, 2015).

Music therapy has previously been used in the care of pregnant women, but only a few studies have investigated whether music therapy relieves pregnancy-related stress and anxiety (Bauer, Victorson, Rosenbloom, Barocas, & Silver, 2010; Carolan, Barry, Gamble, Turner, & Mascareñas, 2012; Chang et al., 2008; Collins Cook, 2012; Kaufmann, 2014). The findings of Chang et al. (2008) show that listening to soothing music for half an hour daily significantly decreased stress, anxiety and depression after a two-week period. Bauer et al. (2010) found that live music and recreation therapy significantly reduced antepartum-related distress in women hospitalized with high-risk pregnancies. In a similar context, Nussberger (2014) found short-term live music therapy to be relaxing. Listening to music has also been found to increase satisfaction with nursing care: blood pressure was reduced but did not have a significant effect on anxiety in pregnant women with preeclampsia (Toker & Kömürcü, 2017). Sidorenko (2000) studied medical resonance therapy in treatment of women with high-risk pregnancies and found that a ten-day music intervention reduced the rate of premature births, reduced stress and cortisol levels, and lowered the heart rate. Moreover, the women slept better and needed fewer painkillers, and systolic blood pressure was reduced for those whose blood pressure was initially high. A recently published review and meta-analysis evaluated the effectiveness of music-based interventions, and indicated reductions in levels of stress and anxiety among pregnant women (Corbijn van Willenswaard et al., 2017).

Music therapy may contain live or recorded music, and some studies have compared the effects of these variations on hospitalized patients (Arnon et al., 2006; Bailey, 1983; Garunkstiene, Buinauskiene, Ingrida Ulozienec, & Markuniene, 2014). According to these studies, live music therapy would be more effective and beneficial for the patient. However, the effects of live music therapy on the HRV and self-reported stress and anxiety among hospitalized pregnant women have not been previously studied.

We empirically studied the novel problem of how live music therapy affects HRV and self-reported stress and anxiety among hospitalized pregnant women. According to our hypothesis, women receiving live music therapy have higher HRV than the women in the control group, and repetition enhances the effect of music therapy. Second, we hypothesize that music therapy reduces the levels of self-reported stress and anxiety more than resting. Third, we hypothesize that women who initially are more anxious, will benefit more from the music therapy. Furthermore, we wanted to investigate whether the first and the second half of the music therapy session might affect HRV measures differently.

Methods

Study design

The study was designed as a randomized controlled trial (RCT). On the first day of the experiment the pregnant women on the ward received a detailed explanation of the goals and procedures of the study, and thereafter gave signed informed consent. The participants were then randomly assigned to either the music therapy group ($N = 52$) or the control group ($N = 50$). The music therapist performed the allocation

by drawing lots. Only the music therapist saw the randomization list, and it was stored according to the Ethical Approval. The random assignment into groups was performed before any data collection (e.g. questionnaires on stress and anxiety levels, or physiologic data) took place, and the group assignment was not altered during the course of the study. The music therapy group received live music therapy on three consecutive days, for half an hour at a time. The women in the control group were instructed by the music therapist to rest in their bed for comparable time periods and were left alone during this time. The music therapist informed the participants in the control group when the time of rest started and ended. The instruction to rest was in conjunction with the instructions given by the physician and the nurses at the ward: to spend time in the bed and try to find a comfortable resting position. The experienced levels of stress and anxiety were measured with Perceived Stress Scale (PSS) and State Scale of the State-Trait Anxiety Inventory (S-STAI). The participants completed the questionnaires both before and after the intervention. The physiological stress levels of the participants were assessed by measuring their HRV.

Participants and settings

The participants of the study ($N = 102$) were pregnant women (mean age 31 years, range 18–47) who were hospitalized due to pregnancy-related complications. Sample size estimate was based on previous work in the field, reporting significant findings with similar groups of participants (Bauer et al., 2010; Chuang et al., 2012b; Toker & Kömürçü, 2017; Yang et al., 2009) and on the estimated number of participating patients on the ward. The study included all the volunteers that matched the eligibility criteria: (1) a minimum age of 18 years, (2) the prospect of spending four or more days in inpatient care (estimated by a nurse), and (3) fluent speaker of Finnish or Swedish. Altogether 148 participants were screened for eligibility. Forty-six women declined to participate in the study. The most common reason for declining was that the mother felt unable or unwilling to concentrate on anything new because of the stressful circumstances. Some mothers declined due to unwillingness to wear the measurement device (Figure 1).

The study took place on the antenatal ward at the Helsinki University Hospital in Finland from April 2013 until November 2014. The ward has 19 beds for antenatal and labor induction patients. Patients were admitted to the ward due to various problems related to pregnancy. The most common diagnosis was the risk of premature delivery. These patients had for instance premature rupture of membranes or uterine contractions with shortened cervix. Both pregnancies with singletons and twins were represented. Other subgroups were women with hypertensive problems like preeclampsia, fetal growth restriction from different origins, antenatal bleeding and maternal diabetes. The average stay on the ward was 3 days. We were not able to collect the individual medical records of the women participating in our study, but we estimated that there was no difference between the therapy and control groups in the reasons for admission to the ward. Thus, the characteristics of the pregnancy complications are unlikely to have interfered with the results.

Permission for the study

The study complies with the Declaration of Helsinki and was approved by the Ethical committee of Women and Child Psychiatry in the Hospital District of Helsinki and

Figure 1. Flow chart of participant enrollment.

Uusimaa (391/13/03/03/2012). The research permission was granted by the department of Women and Children Diseases of the Helsinki University Central Hospital, Hospital District of Helsinki and Uusimaa (Permission: 07.03.2013). Each participant was informed both orally and in writing regarding the course of the study, that the collected data would be recorded anonymously, and that their personal information would be kept confidential. The participants were encouraged to ask for more information at any time. Written informed consent was obtained from all participants.

Intervention

In anthroposophical music therapy, the lyre is used as an instrument that addresses the middle part of the human being in a way that is liberating and enhances a more

inward experience (Reinhold, 2012). Its gently resounding tone quality can encourage general relaxation and relieve congested breathing, pain and tension. The sound of the lyre is gentle, soft and pleasantly enveloping. It opens up a space for sensitive listening and creates a calm atmosphere.

This research included two different lyre instruments: a seven-stringed pentatonic Auris children's lyre from Sweden (<http://auris-musical-instruments.com/lyres>) and a Tao-lyre built by R. Benedek, Germany (<https://www.aeterherz.de/startseite/english/>). The word tao signifies the primordial essence or fundamental nature and balance of the universe. Inspired by the Austrian philosopher Dr. Rudolf Steiner, the Tao-lyre was created as a therapeutic instrument by a music therapist Victoria Ryan in Vienna and a German constructor of instruments Andreas Lehmann. The Tao-lyre, a vibroacoustic instrument, has 48 strings but only four tones: b, a, e, d. Each tone has three strings and the tones extend over four octaves. The sound level of these lyres is 5–68 dB. In a therapy session the sound intensity is adjusted individually to each patient for a comfortable level, and kept between 10 and 35 dB.

The live music therapy included playing of the two lyre instruments and humming beside the bed of the patient. The duration and intensity of the intervention was planned by a trained and experienced music therapist, who took into account her experiences of the needs and preferences for music therapy in pregnant women, and the information of the mean stay of the patients of the ward. The music was adjusted individually to avoid any kind of overstimulation and the participants were asked if they had a favorite lullaby. First, the pentatonic lyre was placed and played on the abdomen of the patient who was comfortably lying on her back. Lullabies were hummed according to the patient's wishes. The patients were also encouraged to hum along and after the first half of the therapy session they were offered the opportunity to play the lyre themselves, however, only a few were willing to do so. Thereafter, the music therapist played the Tao-lyre positioned on the legs of the participant. After that, the patient turned to lie on her side, and the Tao-lyre was played against her back. The lyre was touching the body so that the sound would resonate stronger within the body. The resonance and the sound of the lyre helped the women to focus on their own body and the baby. This offered them an opportunity to become aware of breathing and possible tensions. Four of the participants did not wish the lyre to touch their bodies, and therefore the lyre was played by their side.

Outcomes

HRV refers to the alteration in time between consecutive heart beats (Berntson et al., 1997). HRV was calculated from the electrocardiogram (ECG) recorded at 1000 Hz using a single lead (two electrodes) with the *Firstbeat Bodyguard* device (Firstbeat Technologies). The goal of HRV analysis is to investigate the natural, minor variations in the heart rhythm. The basis for the analysis is a so-called RR (interbeat) interval time series derived from the ECG, describing the time (in milliseconds) between successive R-peaks in the ECG waveform. On the first day of the study, the device was attached by the music therapist to the skin of the patient: one electrode below the right clavicle and the other electrode on the lower left rib cage. The data was recorded continuously during the three days of the study and the device was to

remain in place, except during showering. After the three-day period, the device was removed.

HRV data was collected from a total of 102 participants. The full three-day data set was available from 71 participants. Of the participants in the music therapy group 38 women received the intervention during 3 days, 11 women during 2 days and 3 women during 1 day. In the control group the corresponding numbers were 33 women during 3 days, 7 women during 2 days and 10 women during 1 day. The 31 dropouts were mostly due to the experiment ending in delivery (3 women) or the mother leaving the hospital (15 women) and in 13 cases due to skin irritation caused by the ECG electrodes.

The participants were asked to provide personal information on a questionnaire which consisted of nine questions concerning their age, the gestational age of the fetus, their education, profession, earlier pregnancies, number of children, reason for hospitalization, diagnosis, and the date of arrival at the hospital.

A shortened, 5-item version of The Perceived Stress Scale (PSS; Cohen, Kamarck, & Mermelstein, 1983; Pesonen et al., 2008) was used to evaluate the participants' self-reported stress level before and after the intervention. The questions included for instance: *"In the past two weeks, how often have you felt that things were going your way?"*, *"How often have you felt that you were unable to control the important things in your life?"*, and *"How often have you felt nervous and stressed?"* The responses were given on a 5-point Likert scale (1 = never, 5 = very often).

Self-reported anxiety before and after the intervention was evaluated with The State-Trait Anxiety Inventory (STAI, Spielberger, Gorsuch, & Lushene, 1970). The questionnaire is composed of 20 items each making a statement, such as *"I feel calm,"* *"I am worried,"* and *"I feel confused."* Half of the statements describe positive feelings (*"I feel comfortable"*), and the other half negative (*"I feel frightened"*). The participants were instructed to mark on a 4-point Likert scale how much they agreed with the statement at that moment (1 = not at all, 4 = very much so).

Data preprocessing and statistical analysis

The analyses were made using R (version 3.1.1 GUI 1.65 Mavericks build; R Core Team, 2014). The *colibri* R-package (Henelius, 2014) was used to analyze the HRV data. The sessions of music therapy (or rest in the control group) lasted 20–30 min and the HRV was analyzed from these periods. Artifacts were automatically removed using the method by Xu and Schuckers (2001). On the basis of visual inspection of the data, ten measurement sessions (i.e. therapy or rest sessions) were removed due to bad signal quality.

The data from each session was divided into segments with a length of 2.5 min. The segment length was chosen to be shorter than the usual five minutes in order to minimize the effects of motion artifacts due to the participant changing her position. During late pregnancy, and especially during compromised pregnancies as experienced by the participants of this study, the comfortable position of the mother is of extreme importance. For this reason, participants wanted to change their position often. The data segments in which the maximum heart rate exceeded the mean value of the data from the full measurement session by more than two standard deviations (SD) were excluded from the analysis as they would likely contain excessive noise and/or artifacts. For each included segment, time-domain, frequency-domain and geometric HRV metrics were computed. The time domain

metrics were: mean heart rate (i.e. beats per minute), median heart rate, RMSSD (root-mean square of successive RR-interval differences), SDNN (standard deviation of normal RR-intervals), and pNN50 (the proportion of pairs of successive normal-to-normal RR-intervals differing more than 50 ms). The frequency-domain metrics were estimated using the Lomb-Scargle periodogram (Scargle, 1982). The frequency domain metrics were: power in the low-frequency (LF: 0.04–0.15 Hz) and high-frequency (HF: 0.15–0.4 Hz) bands, commonly used in HRV analyses (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). The ratio of power in the LF to HF band (LF/HF) was also computed. Additionally, the normalized values of both LF and HF were calculated. The geometric metrics used were Poincaré plot indices, SD1 and SD2. The Poincaré plot is a visualization of the HRV signal in which each RR-interval is plotted against the preceding RR-interval. A common technique is to fit an ellipse to the shape of the Poincaré plot, where the dispersions (or standard deviations) along the minor and major axis of the ellipse are referred as SD1 and SD2, respectively. SD1 is known to describe short-term and SD2 long-term variability of

Table 1. Description of different HR and HRV metrics measured during the sessions.

Metric	Unit	Description	Reflects	Indication of relaxation (e.g. low mental stress)	Reference
Mean HR	bpm	Mean heart rate	Relative balance between sympathetic and parasympathetic systems	Lower values	Taelman, Vandeput, Vleminck, Spaepen, & Van Huffel, 2011
Median HR	bpm	Median heart rate			
SDNN	ms	Standard deviation of normal-to-normal RR-intervals	Total HRV	Higher values	Taelman et al., 2011
RMSSD	ms	Root-mean square of successive RR-interval differences	Parasympathetic activity	Higher values	Taelman et al., 2011
pNN50	%	Proportion of pairs of successive normal-to-normal RR- intervals differing more than 50 ms	Parasympathetic activity	Higher values	Taelman et al., 2011
LF	ms ²	Power in low-frequency band (0.04–0.15 Hz)	Both sympathetic and parasympathetic activities	Lower values	Delaney & Brodie, 2000
LF.n	-	Normalized value of LF $LF.n = LF/(LF + HF)$			
HF	ms ²	Power in high-frequency band (0.15–0.4 Hz)	Parasympathetic activity	Higher values	Delaney & Brodie, 2000
HF.n	-	Normalized value of HF $HF.n = HF/(HF + LF)$			
LF/HF	-	The ratio of power in LF to HF band	Sympatho-vagal balance ^a	Lower values	Delaney & Brodie, 2000
SD1	ms	Poincaré plot index – Standard deviation of short-term RR-interval variability	Parasympathetic activity	Higher values	Melillo, Bracale, & Pecchia, 2011
SD2	ms	Poincaré plot index – Standard deviation of long-term RR-interval variability	Both sympathetic and parasympathetic activities	Higher values	Melillo et al., 2011

^a Widely accepted to describe the sympatho-vagal balance. However, this view has also been increasingly challenged, see more, e.g. Eckberg (1997) and Billman (2013).

the RR intervals. The common behavior of the different HR and HRV metrics during relaxation is reviewed in [Table 1](#) (see also review article Shaffer & Ginsberg, 2017). When interpreting the results, it is important to note that many of the HRV metrics strongly correlate with each other (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). Especially, in individuals without heart problems the calculation of SD1 and SD2 produce very similar, or identical values to RMSSD and SDNN respectively (Brennan, Palaniswami, & Kamen, 2001; Carrasco, Gaitán, González, & Yáñez, 2001; Karmakar, Khandoker, Gubbi, & Palaniswami, 2009). Also, the frequency measures typically correlate strongly with each other [e.g., $R(\text{HF} \times \text{LF}) = 0.53$, $p < .01$, Tulppo, Makikallio, Takala, Seppanen, and Huikuri (1996)] and the non-normalized variables of HRV are more strongly correlated with HR than normalized values (Sacha, 2013; for a comprehensive representation of correlations between HRV metrics measured at rest, see Tulppo et al., 1996). Therefore, to avoid increase of type II errors, the results are reported with no corrections for multiple testing (see, for instance, the review by Sinclair, Taylor, & Hobbs, 2013).

Linear mixed models were employed for statistical comparisons using the *lme4* R-package (Baayen, Davidson & Bates, 2008). The dependent variable of the model was a HRV metric (with separate models for each HRV measure). Group (music therapy/control), measurement day (1, 2, 3), segment and age were included in the model as independent fixed effects, and participant was included as the random effect. The significance of the interaction was tested using likelihood ratio tests by comparing the model with and without the interaction. Further, the *car* R-package was used to calculate the Wald chi-square test results reported below in the result section.

The within-group (therapy or control) differences in state anxiety and stress before and after the study were assessed using paired sample *t*-tests.

Next, the sample was divided into two subsamples based on the self-reported state anxiety in the beginning of the experiment: score 40 or more representing high state anxiety and 39 or under representing moderate state anxiety (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983; Lin, Hsieh, Hsu, Fetzer, & Hsu, 2011). The high-anxiety group included 70 participants (39 in the music therapy group), and the moderate-anxiety group included 31 participants (13 in the music therapy group).

The repeated measures *t*-test was employed to compare the two subsamples with respect to the effects of the music therapy on perceived stress and anxiety. This analysis was also conducted for the two subsamples (two separate models).

Results

Background information

[Table 2](#) shows the participants' background information that was collected for the study. The groups did not significantly differ in terms of age, duration of the pregnancy, education, or number of children. The initial self-reported anxiety in the music therapy group was slightly higher than in the control group. The perceived stress estimates measured with the PSS did not differ before the intervention. Moreover, in the highly anxious subgroup, the music therapy group contained more participants who were able to participate in only two out of three sessions.

Table 2. Group-level background information of participants included in the study.

Variable	Music therapy	Control		
<i>N</i>	52	50		
	Mean (<i>SD</i>)	Mean (<i>SD</i>)	<i>t</i> value	<i>p</i> value
Age	30.6 (6.9)	31.0 (5.4)	0.39	.70
Gestational age (in weeks)	28.7 (3.1)	28.2 (3.4)	0.89	.37
Perceived stress (PSS) ^a – Pre	3.0 (0.8)	2.7 (0.7) ^c	1.76	.08
Perceived stress (PSS) ^a – Post	2.9 (0.8)	2.7 (0.7)	0.93	.36
Symptoms of anxiety (S-STAI) ^b – Pre	2.4 (0.6)	2.2 (0.5) ^c	2.20	.03*
Symptoms of anxiety (S-STAI) ^b – Post	2.2 (0.6)	1.9 (0.4)	2.47	.02*
Education	<i>N</i> (%)	<i>N</i> (%)		
Basic education	4 (7.7)	3 (6.0)		
Upper secondary level	22 (42.3)	20 (40.0)		
Lower academic degree	12 (23.1)	12 (24.0)		
Higher academic degree	13 (25.0)	11 (22.0)		
Missing information	1 (1.9)	4 (8.0)		
Number of children				
0	28 (53.8)	23 (46.0)		
1	18 (34.6)	17 (34.0)		
2	5 (9.6)	7 (14.0)		
3	1 (1.9)	3 (6.0)		

^a Shortened, five-item version of the Perceived Stress Scale.

^b The State-Trait Anxiety Inventory.

^c Data from 49 participants.

* $p < .05$.

Figure 2. Changes in SD2 of the heart rate during a therapy or a control session.

Note. The figure shows the mean values of the SD2 (a nonlinear, geometric parameter reflecting the deviation of the heart rate) during a therapy or a control session. The error bars illustrate the standard error of mean (SEM). Higher SD2 values are generally related to more relaxation (Table 1). Corresponding changes in the other 11 HRV measures are shown in Supplemental Figure 2.

Heart rate variability

The linear mixed effects modeling showed that 10 of 12 HR/HRV measures did not show significant effects. The significant effects were the following: SD2 increased more during the therapy sessions than during the control (rest) sessions [$\chi^2(2) = 4.9$, $p = .027$; Figure 2]. The HF increased more in the control condition than in the therapy condition [$\chi^2 = 8.31$, $p = .004$], but the interaction was not significant with normalized (HF.n) values [$\chi^2 = 1.33$, $p = .25$]. With Bonferroni adjustment the effect on SD2 is not significant.

Comparing the three sessions, 7 of the 12 HRV metrics did not show significant differences. The significant effects were as follows: SDNN was more decreased in later sessions of the therapy group than in the control group [$\chi^2 = 12.3$, $p = .002$]. Moreover, the SD2 decreased from a session to another in the therapy group [$\chi^2(2) = 11.4$, $p = .003$]. The LF decreased between the sessions in the therapy group more than in the control group [$\chi^2(2) = 12.7$, $p = .002$; Figure 3]. The normalized values (LF.n) also showed significant differences [$\chi^2(2) = 7.73$, $p = .02$]. HF.n slightly increased between the sessions in the therapy group, whereas it slightly decreased between the sessions in the control group [$\chi^2(2) = 7.73$, $p = .02$]. With Bonferroni adjustment the effects on LF.n is not significant. The other HRV outcomes between therapy sessions (Supplemental Table 1 and Supplemental Figure 1) and during a therapy session (Supplemental Table 2 and Supplemental Figure 2) are presented in the supplemental information of the study.

Figure 3. Changes in LF of the heart rate over three therapy or control sessions.

Note. The low frequency (LF) variation of the heart rate. Mean values ($\pm$ SEM) in the three therapy or control sessions. Corresponding changes in the other 11 HRV measures are shown in Supplemental Figure 1.

Stress

The paired sample *t*-test showed that the stress did not differ significantly within the therapy and control groups before and after the intervention: music therapy group *t* (1,42) = −1.31, ns. and control group *t*(1,35) = 0.30, ns.

Anxiety

The *t*-tests revealed that in the entire study sample, the state anxiety was significantly reduced during the study period, on average by 6.2: *t*(1,60) = 5.016, *p* < 0.001 (two-tailed). Further, when the therapy and control groups were separately examined, the state anxiety was significantly reduced in both groups: music therapy group *t*(1,31) = 3.10, *p* < 0.004 (two-tailed) and control group *t*(1,28) = 4.11, *p* < 0.000 (two-tailed). When the amount of change in state anxiety (before-minus-after treatment) was compared between groups, there was no significant group difference [*F* (1,59) = 1.707, *p* = .73]. In the control group the mean anxiety score was −1.27 before the intervention and −7.93 after the intervention, that is, the mean anxiety decreased with 6.66. The women in the therapy group had a mean score 2.09 and the anxiety decreased after the intervention (mean score −3.69), showing a reduction of 5.78 units.

For the highly anxious participants, SDNN increased within a therapy session [*F* (1,1516) = 4.44, *p* = .04]. For the moderately anxious participants, mean HR decreased within a therapy session [*F*(1,690) = 9.52, *p* = .02]. HRV metrics of the highly anxious participants did not differ between therapy sessions. However, in the moderately anxious group, mean HR, RMSSD, and pNN50 differed between the therapy and control sessions. Figure 4 shows that the second therapy and control sessions differed from the first and the third sessions.

The level of self-reported anxiety of the highly anxious participants was reduced both in the music therapy [*t*(31) = 3.74, *p* < .001] and control groups [*t*(22) = 4.09, *p* < .001], but there was no difference in the magnitude of the reduction between the

Figure 4. Changes in mean heart rate, RMSSD, and pNN50 in moderately anxious participants.
 Note. The variation of mean heart rate, RMSSD and pNN50. Mean values (±SEM) of the moderately anxious subgroup in the three therapy or control sessions.

groups [$F(1,118) = 0.27, p = .60$]. In contrast, the moderately anxious participants reported no change in the levels of anxiety and stress.

Discussion

This study aimed to assess changes in stress and anxiety in hospitalized pregnant women both with HRV and with questionnaires with respect to receiving live music therapy. We succeeded in collecting a valuable and unique set of data combining repeated physiological measurements and assessments of self-reported stress and anxiety in pregnant women. We found positive effects of live music therapy on the HRV in this group of participants. The data did not directly support the first hypothesis: in general, HRV was not significantly greater in the group of women who were randomly assigned to the live music therapy group. However, out of the 12 HRV measures only SD2 increased during the music therapy session, which may indicate that live music therapy helped the pregnant hospitalized women to relax more during the therapy session. This is an interesting result which is in line with previous research showing that music therapy increases HRV and can thus reduce anxiety in pregnant women (Bauer et al., 2010; Sidorenko, 2000; Yang et al., 2009). It is important to note that the relaxation of the mother during the late part of the pregnancy, and especially in complicated pregnancies as in the case of the participants in this study, is extremely important for a good birth outcome. For this reason, any method that can be safely used to help the relaxation of these mothers is medically relevant and useful. The results also show that effects can be observed already in a short time period of 20–30 min.

When considering the longer-term effects of live music therapy, that is, effects that occur from one session to the next, our hypothesis was not directly supported by the data. LF indicated that the participants were more relaxed on successive live music therapy sessions, which has also been found in previous studies, whereas the other measures did not support the hypothesis. Thus, we were not directly able to conclude the cumulative beneficial effects of participating in the music therapy on three consecutive days, even though one of the measures suggested a positive session-to-session effect. On the basis of this study, we cannot conclude whether repetition enhances the effect of music therapy. Rather, the effect might be partially temporary: Even though the women become relaxed during the therapy, by the next day they might be anxious again because of their worries and the hospital environment. The results comparing the three sessions might reflect differences in the baseline HRV of each day instead of the pure effect of music therapy, since only the data of the different therapy/rest sessions from the whole intervention were included in the analysis. In addition, the physiological responses in pregnant women may be suppressed compared to non-pregnant women, as some studies found no physiological response at all, although the self-reported anxiety was relieved (Chang & Chen, 2005; DiPietro, Mendelson, Williams, & Costigan, 2012). Additionally, the women with higher gestational age may have experienced more stress (Dennis et al., 2017).

The self-reported anxiety was significantly reduced in both the music therapy and control groups, but there was no difference in the amount of reduction. Moreover, when the groups were further divided by their initial level of anxiety to groups of high and moderate anxiety, no significant differences were found between the music therapy and control groups. The perceived stress was not found altered in any of the

comparisons. The reduction in the perceived stress may have resulted from the progression of the pregnancy, reducing the risk of premature birth and severe complications. It should also be noted that the condition of our participants varies highly from one day to the next especially when the health of the fetus or the mother changes abruptly. This may have resulted in high deviation in the self-reported stress and anxiety in our patients, and such variation may possibly be much larger than that caused by live music therapy.

In some previous studies, pregnant women have reported lower levels of stress and anxiety following a music therapy intervention (Chang et al., 2008), whereas other studies report no change in the anxiety levels (Toker & Kömürçü, 2017). In the current study, the questions concerning the self-reported stress might have been too general (*"in the past two weeks"*), and the questions about anxiety too bound to the specific moment to reflect the relaxing effect of the three short music therapy sessions. The results might have been different if we had instructed the pregnant women to fill in the forms right after the music therapy session. In our study, they had the opportunity to fill in the questionnaires one day later.

It was assumed that the stress experienced by the participants is mostly an acute reaction to the hospitalization and the health issues of the mother and the fetus. We did not assess chronic stress factors, which may nevertheless have contributed to the complications in the pregnancy and also to the stress levels during the inpatient care (Paarlberg, Vingerhoets, Passchier, Dekker, & Van Geijn, 1995).

Study limitations

Unfortunately, despite the random assignment into the groups, the initial self-reported anxiety in the music therapy group was slightly higher than in the control group, which may have affected the comparability of the groups. Moreover, the participants' musical involvement or training was not asked, and musicians and nonmusicians may have different physiological responses to music (Bernardi, Porta, & Sleight, 2006). However, none of the participants reported a music-related profession.

In the music therapy group the music therapist was present during the whole therapy session whereas the participants in the control group were left alone and asked to rest in their bed. However, five of the participants in the control group were once found at the end of the resting time speaking on the phone, one participant was watching TV, one was knitting and one had family members visiting.

Another limitation of the study is the dropout rate, which was not possible to avoid due to the situation of the participants. The electrodes of the HRV measurement device caused skin irritation for a fairly large number of women. If non-irritating electrodes could be used the women would presumably wear the device longer. The missing data points were taken into account in the statistical analysis. Also, breathing has been found to affect HRV (Billman, 2011), but in this study we chose not to control breathing, in order to focus on the effects of music therapy and not on those of guided breathing.

We did not collect more specific details or diagnosis from the medical records of the participants. This might be one more limitation of the study. On the other hand,

the amount or type of anxiety and stress are not necessarily bound to the medical condition of the mother or fetus. Thus, they probably have no or a minor effect on the mother-fetus connection in this context.

Recommendations for clinical practice

The personnel on the ward appreciated the opportunity to offer patients music therapy given by a trained music therapist as a non-pharmacological option that may help the women relax as well as relieve stress and anxiety. High-risk pregnant women, and their infants (fetuses) are at real risk of experiencing trauma, and may face various future medical complications connected to the infant neural development, psycho-emotional development and the parent-infant attachment patterns. It is of utmost importance that pregnant women in the hospital find ways to relax. Providing music therapy to this population is aimed to prevent the high-risk pregnancy and the premature birth from becoming a traumatic event, and to help parents to cope better in this fragile situation. Music therapy can provide a break from the hypervigilance which is especially harmful when continuous. Music therapy could therefore be used in the future as common practice for pregnant women on the ward.

On the basis of this study and other previous studies, it would be a good practice for hospital personnel to assess the stress levels of their patients on a regular basis and actively offer music therapy: live music when available, or recorded music. This would ensure that the patients who are open to receive music therapy have the opportunity to do so.

Receptive music therapy does not require physical activity or much mental energy from the patient, so it is easy to implement even in the challenging situations the pregnant women are facing. Music therapy could also be used outside the hospital environment, in outpatient care or even at home.

Suggestions for further studies

It would be important to assess the long-term effects of live music therapy, perhaps with more therapy sessions and including a longitudinal design, so that the development and health of both the mother and the child could be assessed for one year after delivery. It could be useful to include a baseline measurement of the HRV in the analysis and a follow-up measurement some time after the end of the therapy. The control group could receive an alternative intervention for relaxation in order to compare the benefits of music therapy to other relaxation methods. In the present study, the empathetic presence of the music therapist may in itself have given the participants the experience of being nurtured, whereas the music therapist was not present with the resting control group. The study also prompted new research questions, such as whether music therapy influences the fetal HRV, and whether music therapy could help to relax when suffering from premature contractions, or having troubles with or anxiety related to breastfeeding.

Conclusions

The SD2 HRV measured from pregnant hospitalized women increased during live music therapy sessions, which may indicate that live music therapy helped the

women to relax. Relaxation is important especially for women suffering from pregnancy complications, since relieving stress can promote the wellbeing of the mother and the fetus. Therefore, it is recommended that music therapy is offered for pregnant women.

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Disclosure statement

The authors of the study declare that they have no conflict of interest regarding the study.

Notes on contributors

Pia Teckenberg-Jansson, music therapist, got her music therapy education and exam at the Musiktherapeutische Arbeitsstätte in Berlin, Germany, in 2004. She is working in Helsinki on an antenatal ward with pregnant women, in various nursing homes for elderly suffering from dementia and also in palliative care. Previous research projects of music therapy for prematurely born children.

Siiri Turunen received her Master of Psychology degree at University of Helsinki, Finland, in 2016, and her M.Phil. degree in cognitive science in 2013. She is currently working as a clinical psychologist at a psychiatric hospital. She has also worked among children and families.

Tarja Pölkki, R.N., Ph.D., Adjunct Professor, is working as a specialist in clinical nursing science in the unit of Children and Women in the Oulu University Hospital, Finland. Her research interests include pain assessment and pain management, focused especially on non-pharmacological methods, among pediatric patients, as well as family-centered care. Tarja is also a member of PEARL (Pain in Early Life) research group.

Minna-Johanna Lauri-Haikala received her Master of Psychology degree from University of Helsinki, Finland, in 2016. She is currently working as a school psychologist. She has also worked at a children's hospital.

Jari Lipsanen received his Master of Psychology degree from University of Helsinki, Finland, in 2006. Currently working as lecturer of psychometrics in Department of Psychology and Logopedics, in University of Helsinki.

Andreas Henelius received his D.Sc. (Tech.) degree in computer science from Aalto University in 2017. His current research interests include the use of randomization methods in data mining.

Ansa Aitokallio-Tallberg M.D., Ph.D. Specialist in Obstetrics, Gynecology and Perinatology Working as senior consultant on department of Obstetrics and Gynecology at University hospital in Helsinki.

Satu Pakarinen received her Doctor of Psychology degree from University of Helsinki, Finland, in 2011. Her current research focuses on measuring the effects of acute and prolonged stress on human physiology and performance as well as on health and wellbeing.

Marianne Leinikka received her M.Sc. (Tech.) degree in bioinformation technology from Aalto University, School of Electrical Engineering, in 2014. Her expertise is in the experimental work in physiological measurements both in laboratory as well as real-life settings and in the analysis of them.

Minna Huotilainen is a Professor of Educational Sciences at University of Helsinki, Finland. She is best known for her work in studying auditory brain responses in infants and fetuses and showing the benefits of musical training for children and adolescents as well as for her studies on neuroscience of work.

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