Acute relaxation during pregnancy leads to a reduction in maternal electrodermal activity, changes in cardiovascular activity and subjective stress levels depending on the week of gestation.

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Abstract

Background: Prenatal maternal stress can have adverse effects on birth outcomes and fetal development. Relaxation techniques have been examined as one potential countermeasure. This study investigates different relaxation techniques and their effect on mood and physiological stress levels in pregnant women.

Methods: 36 pregnant women (30 to 40 weeks of gestation) were randomly assigned to one of three groups: music, guided imagery or resting. Dependent measures included self-report questionnaires, subjective ratings of stress levels as well as physiological measures, i.e. cardiovascular and electrodermal activity.

Results: All three forms of relaxation led to reduced maternal stress: decreased heart rate and decreased skin conductance levels. Based on heart rate, skin conductance level and stress ratings there were no significant differences between relaxation interventions. Subjective post-intervention stress ratings indicated that more relaxation occurred after intervention in earlier gestation than in late gestation.

Conclusion: Independent of relaxation technique, a 20-minute period of acute relaxation can reduce maternal stress. Notably, women earlier in pregnancy reported to be more relaxed after the intervention than women later in gestation. Hence, gestational age can influence perceived stress levels and should be considered when evaluating relaxation or stress management interventions during pregnancy.

Keywords: pregnancy, relaxation, maternal stress

1. Background

Pregnancy is characterized by various personal expectations, hormonal changes and a new coordination of the professional and social environment, often including financial or health concerns.[1–4] Intense emotional states are often associated with this period of life.[5] Several studies have shown adverse effects of intense negative maternal emotional states, ranging from prenatal distress to peripartum mental disorders, on fetal and infant development.[6–11] More specifically, adverse effects on the physiological, metabolic and neuronal development of the fetus - affecting amongst others fetal heart rate, sleep patterns and activity with possible long-lasting consequences - have been reported.[6, 12, 13] The fetal autonomic nervous system reacts quickly and adaptively to environmental changes: Higher fetal heart rate variability and lower fetal heart rate have been used as indicators for fetal wellbeing. Accordingly, several studies have shown that elevated maternal depressive or stress symptoms lead to changes in fetal cardiovascular activity.[6, 14–20] Furthermore, recent studies reported a relation between maternal stress and offspring's physiological stress reactivity, cortisol values and birth outcome.[21–28] Altered maternal cortisol levels have been hypothesized to be related to emotional and behavioral psychopathology across the child's lifespan and potentially affect cognitive performance and brain volume in children.[29–31] Additionally, maternal diurnal cortisol was related to newborn's stress reactivity and therefore the developing hypothalamic-pituitary-adrenal axis measured by a neonatal heel-stick measurement.[32]

Therefore, in order to avoid or compensate expected adverse effects caused by maternal stress, preventive measures such as relaxation techniques become increasingly important. So far, most studies indicate that maternal relaxation during pregnancy can reduce maternal stress and improve maternal wellbeing.[33, 34] Especially interventions based on mindfulness are becoming more popular. It is based on the concept of paying attention to internal and external factors in the present moment. [35] Mindfulness-based interventions are also known as effective ways of treatment in mental disorders. [36] In pregnant women a significant number of studies have shown that relaxation strategies only show positive effects on the maternal autonomic nervous system but also reduce symptoms of maternal anxiety and depression.[20, 37–44] For instance, DiPietro et al. [45] used a 18-minutes guided imagery and music for relaxation during the third trimester of pregnancy. Significant changes in maternal heart rate (MHR) and skin conductance level (SCL) were shown. A questionnaire-based study by Nwebube et al. [39] detected lower anxiety and depressive symptoms in the intervention group who listened to music during pregnancy for 12 weeks. Also using music for relaxation, a significant decrease in maternal systolic and diastolic blood pressure, heart rate [46] and uterine contractions [47] after a prenatal music intervention have been reported. Moreover, relaxation can have positive effects on the experience of maternal pain during labor [48, 49] can lead to lowered cortisol levels in women during pregnancy.[38, 50]

Moreover, various types of relaxation, such as music-based interventions, can have positive effects on the offspring, as shown in premature infants.[51] It was shown that listening to music on a regular basis do enhance the functional connectivity in preterm newborns in a Neonatal Intensive Care Unit environment. In the last decade, several studies reported significant effects of different relaxation types on fetal and neonatal development.[43, 52] For instance, the DiPietro et al. study [45] did not only show effects on mothers, but also a reduced fetal heart rate and increased fetal heart rate variability. In summary, a positive influence of different relaxation techniques on fetal and neonatal development as well as on the mother's wellbeing can be assumed.[38, 50]

The majority of studies investigating influence of relaxation techniques on maternal and fetal wellbeing used inconsistent methods. There is a wide heterogeneity regarding the type of relaxation (active/passive, body-based, mental-based) and also regarding the duration and frequency (regular, one-time, weekly). Physical relaxation techniques may not be suitable for every woman during pregnancy, so the need for evidence-based mental techniques that can be used regardless of a woman's physical condition has increased. Additionally, it is not known whether active or passive relaxation without involving the body within the relaxation is more effective for pregnant women.

To our knowledge, no study directly compared different mental based active/passive relaxation interventions in pregnant women. Therefore, the present study focuses on the question which kind of mental-based active and passive relaxation technique leads to greater relaxation during pregnancy.

Three commonly used mental-based relaxation interventions: music (listening to music), a guided imagery (following a guided imagery without body-based instructions) and minimal relaxation (resting, i.e. sitting quietly), are compared regarding their effectiveness on maternal physiological and psychological parameters of stress during the third trimester of pregnancy.

The following hypotheses were defined:

(1) We expected that acute relaxation, both with music, guided imagery or resting leads to a decrease in physiological stress levels, i.e. decreased heart rate (HR) and skin conductance level (SCL).

(2) We expected that the effects of the three interventions differ showing a stronger effect on physiological parameters during the relaxation with music or guided imagery compared to resting.

As we were also interested in the subjective effects of the three relaxation conditions, we exploratively investigated whether subjective stress ratings differed between groups and whether gestational age influenced any of the stress parameters assessed.

2. Methods

The study was conducted between February 2018 and September 2019. The Ethics committee of the Medical Faculty of the University of Tuebingen, Germany, approved this study (748/2017BO1). Informed consent of all participants was obtained prior to the start of the measurements.

a. Participants

Pregnant healthy women were recruited through electronic communication. Eligibility was restricted to women over 18 years of age, German speaking, singleton uncomplicated pregnancy and gestational age (GA) between the 30th and 40th weeks of gestation. Exclusion criteria were hearing impairments, acute depression, mental disorders (self-report) or drug/nicotine consumption during pregnancy (self-report). After an initial information about the study, a single visit was scheduled between 30 and 40 weeks of gestation. A total of 38 women were enrolled. Three out of 36 women stated that they are vegetarian or vegan and one woman stated that she has celiac disease. Regarding previous experience with relaxation, four women reported that they participated in no strict routine activities to encourage relaxation. Of those that did, the most commonly nominated techniques included yoga and meditation, exercising as well as sleeping during day time or reading. However, none of these reported the use of the respective relaxation techniques daily. Three women stated that they also like to listen to music for relaxation on purpose. On average, participants were 30.9 years old, in their 34th week of gestation and 72% were expecting their first child. Nine of 36 women were participating in another measurement just before the reported study where the participants were at rest for 30 minutes but without any specific intervention. Two-third of the women had a college or a higher education/university degree. Participants were informed about the course of the study and gave written informed consent prior to participation.

b. Design and Procedure

The participants were randomly assigned to the *music group*, the *guided imagery group* or the *resting group* just before the measurement started (see *Figure 1*). We scheduled an 1h-visit between 8am and 2pm. During the whole visit an in-house midwife was present. On arrival, fetal vitality was controlled by using an ear trumpet and by implementing a short interview by the in-house midwife. Women were asked to fill out a questionnaire (Profile of Mood States, POMS) to assess their current mood.[53] Additionally, they rated their current stress level on a visual analogue scale (VAS) ranging from 0 (not stressed at all) to 10 (highly stressed).

The relaxation intervention started after the women were positioned in a semi-recumbent comfortable armchair in a noise-reduced room. During the intervention, the light in the room was dimmed. The electrodermal activity- and heart rate monitor was positioned out of view of the participants. Women were asked whether the room temperature was comfortable or not and if they are feeling fine.

For all three groups, we started with a test measurement for three minutes to ensure the functioning of the electrodes, then ten minutes of baseline data were collected. Following, we gave instructions: to sit quietly, breathe calmly and to avoid any movements. After that, the headphones were placed (in the *resting group* too to ensure comparability between conditions) and the intervention was started (only for *music group* and *guided imagery group*) for 10 minutes. The music ("*Find Your Inner Peace*", Rostar) was designed specifically for relaxation, using specific tempos for inducing a calm state, without vocals. The guided imagery text was specifically designed for this study by a midwife for use during pregnancy, based on her professional experience. The guided imagery had no instructions that related to the body to avoid conscious active physical tension and to avoid artifacts in the measurements. For the resting condition, women were asked to sit quietly without moving and to breathe normally. After the relaxation, the women got the opportunity to relax for 10 more minutes. This period was used as recovery measurement (without any specific relaxation intervention). During the whole procedure, our in-house midwife and the study assistant were present in the same room as the woman. After the whole measurement, the study assistant removed the electrodermal activity electrodes, headphones and heart rate monitor.

Afterwards women rated their stress level again on the POMS and VAS and indicated how they experienced the intervention. After their participation, we sent them a link for additional questionnaires via email regarding chronic stress (Trier Inventory of chronic stress (TICS)) and pregnancy-related distress (Prenatal Distress Questionnaire (PDQ)). They filled in the questionnaires a couple of days after the appointment at our center (one to five days) at home. For the computer-based questionnaires we used the software Unipark (www.unipark.de). We included the following questionnaires for the analysis:

Prenatal Distress Questionnaire (PDQ) – Pregnancy-related distress

The Prenatal Distress Questionnaire (PDQ) assesses pregnancy-related concerns as well as concerns regarding birth with 12 items.[54] The questionnaire included five response categories (zero=never to four=extremely often). PDQ scores ranged from zero to 48.

Trier Inventory of Chronic Stress (TICS) – Chronic stress

For the assessment of chronic stress, we used the Trier Inventory of Chronic Stress (TICS) questionnaire.[55] This questionnaire is based on an interaction-related stress concept.[56] According to this concept, stress arises in and through the active confrontation of a person with the demands of their environment. The questionnaire includes 57 items forming 9 different subscales: Work Overload, Social Overload, Pressure to succeed, dissatisfaction with the work, excessive demands at work, lack of social recognition, social tensions, social isolation and chronic concerns. Participants answer using a 5-point-likert scale response format (zero=never to four=very frequently). In addition, it contains a screening scale for chronic stress (SSCS), which uses 12 items to record chronic stress in a non-specific and global manner, which was used for the analysis. An evaluation period of the last three months is requested.

Profile of Mood States (POMS)- Current mood

In the present study the German short form of the POMS with 35 items and a 7-point-likert scale response categories (zero=not at all to six=very strong) was used.[53] The 35 items form the scales of depression/anxiety, fatigue, vigor and hostility. In the POMS, the participants are asked to evaluate

their state of mood regarding the last 24 hours. All questionnaires with a maximum of one missing item per scale (replaced by scale mean) were included in the evaluation (n=1). No questionnaire was excluded due to more than one missing item.

d. Maternal physiological response

Maternal electrodermal and cardiovascular activity were recorded with a four-channel data acquisition and analysis device (MP36R Research System, BIOPAC (USA)). Data were recorded with a sampling rate of 2000 Hz. Electrocardiogram was recorded from three disposable electrodes which incorporate liquid electrolyte gel and moderately-high chloride salt concentration. The electrodes were placed on the forearms of the participants. Data quantification proceeded offline using Matlab R2018a (The MathWorks, Natick, MA). ECG data underwent R-peak detection (in house software), manual editing for artifacts and interbeat interval computation. For the analysis, we divided each complete data set into 5-minutes segments, over which we then calculated the mean value. Our time-domain parameters included root mean square of successive differences (RMSSD), standard deviation of all NN intervals (SDNN) and the HR (beats per minutes (bpm)). Our frequency-domain parameters included high frequency (HF_n, normalized).

Electrodermal activity (quantified by skin conductance level (SCL)) was measured by administering a constant 0.5 Volt root-mean square 35 Hz AC excitation signal and detecting the current flow. Electrodermal activity was monitored from two disposable pre-gelled electrodes. They were placed on the distal phalanges of the index and second fingers of the non-dominant hand. Electrodes were affixed with adhesive tape. Before the measurement women took off their shoes to avoid any sudden spikes in the electrodermal activity trace because of rubber-soled shoes. SCL was scaled from 0 to 25 microsiemens. Data quantification proceeded offline using Biopac software *Acqknowledge5*. The SCL datasets have first underwent a visual inspection in order to detect major fluctuations in the data or artifacts. Noisy data was substituted with linear interpolation based on the values at the left and right edges if necessary.[57] Then the signal was divided into a phasic and a tonic one. In the next step movement artifacts were removed with a median smoothing with 50 samples [57]. For the analysis, values were baseline corrected and the complete data set was divided into 5 minute sections, over which the mean value was calculated. For the analysis, we used the skin conductance level (SCL).

3. Data analysis

Since the interruption concerning the putting on of the headphones for relaxation intervention marks an interruption in our data, we included only segments of beginning of the intervention (relaxation) phase (T1) until the end of the recovery phase (T4) for data analysis (see *Figure 1*). The total time of the relaxation phase and the recovery phase was thus 20 minutes. For the analysis of the maternal physiological activity, we used baseline correction by subtracting the mean of the first five minutes in the beginning (T0) without any intervention from the data measured during the period from T1 to T4.

Testing was discontinued for two participants due to technical issues in the ECG data and discomfort of the woman. The ECG data analysis is based on the remaining 36 participants.

Data preparation of all dependent variables included tests for normality, homogeneity of variances and examination of outliers. If not normally distributed, variables were subjected to transformation by natural logarithm and adding a constant or were ranked before statistical procedures were applied. Outliers were removed if the values were more than three standard deviations from the mean value. Covariates were variables like 'women participated in another measurement before' and chronic stress. Primary analyses for all dependent variables evaluated differences between groups (*music, guided imagery, resting*) in response to the intervention using repeated measures analysis of variance (ANCOVA). Secondary analyses also examined effects of time using a ANCOVA with the between-subject factor group (*music, guided imagery, resting*) and within-subject factor time (T1-T4). For post-hoc analysis we used Bonferroni or Dunnett T3 - correction. In case of a non-normal distribution of the

data, we used a Wilcoxon signed-rank test. To determine differences in dependent variables between groups, we performed a one-way ANOVA.

State and trait questionnaires were analyzed by the standard evaluation procedure of every questionnaire. Data were also analyzed using mixed ANOVAs with group and time as factors.

Before and after the measurement, we asked all participants to indicate how stressed they felt at the moment by using a VAS. This scale is scored from zero (not stressed at all) to a maximum of ten (highly stressed), with a higher number representing a more stressed state. To analyze the VAS, we measured the distance from 0 to the set mark in cm to get the pre (before the measurement) and post values (after the measurement). Regarding the POMS, the calculation of the scale values was done manually as the sum of the subscale item values.

Analysis of differences in VAS between Group 1 and Group 2: For the delta value included in the analysis, we subtracted the pre-value from the post-value for each woman separately. For the regression analysis and ANOVA we used VAS delta to describe changes pre and post intervention.

All statistical analyses described above were performed using the software program SPSS (*IBM SPSS Statistics 26*) and alpha levels was set to $p=.05$.

4. Results

No significant differences were detected between groups in maternal characteristics (i.e. parity) or fetal characteristics (e.g. sex). There was a trend for chronic stress between the three groups, $F(2,34)=3.128$, $p=.057$. Bonferroni post-hoc tests revealed that the main effect was driven by the difference between *music group* and *guided imagery group*, $p=.057$. (see *Figure 4*). Between the groups, there was a trend for a difference in maternal age, $F(2,34)=2.58$, $p=.091$, and none for gestational age, $F(2,34)=2.08$, $p=.142$. In addition, there was a significant main effect of whether 'women participated in another measurement before' between groups, $F(2,34)=6.556$, $p=.004$. Dunnett-T3 post-hoc tests revealed a significant difference between *music group* and *guided imagery group* ($p=.032$) and *music group* and *resting group* ($p=.027$) in terms of whether the women had just previously participated in another measurement at our center or not, therefore women had more time to calm down between arrival and start of measurement. Since these variables differed significantly between the groups or at least showed a trend, they were included in the further analyses. Thus, maternal response patterns were analyzed by including chronic stress and 'participating in another measurement before at our center' as covariates.

Because of missing values or outliers different sample sizes were used for the different analysis: HRV=10 subjects per group; EDA=9 subjects for *guided imagery/music group*, 12 subjects for *resting group*. Group characteristics are presented in *Table 1*.

a. Maternal cardiovascular response to relaxation procedures

We assumed a significant relaxation effect over time within each group in cardiovascular activity. A repeated measures ANCOVA with a Greenhouse-Geisser correction determined that mean maternal heart rate (HR) showed a statistically non-significant difference over time for *music group*, $F(1.174, 7.041) = .792$, $p = .424$ and for *guided imagery group*, $F(3,24)=.958$, $p=.428$ and for *resting group* $F(1.377,11.013)=.063$, $p=.878$. In sum, the mean maternal HR slightly declined in all groups except for *guided imagery group*, but not to a significant extend. In *guided imagery group*, an increase was measured over time, but did also not reach significance (see *Figure 1*).

For maternal heart rate variability (HRV), we used repeated measures ANCOVA with a Greenhouse-Geisser correction. A slight non-significant decline in RMSSD appeared in *guided imagery group*, $F(3,24)=.662$, $p=.584$, a slightly increase in *music group*, $F(1.599,14.392)=.687$, $p=.487$ and a slightly decrease were seen in *resting group* over time, $F(3,9)=.868$, $p=.493$ when adjusted for chronic stress and 'participated in another measurement before'.

All in all, there were no significant differences in MHR (HR, SDNN (Standard deviation of NN intervals)) and HRV (RMSSD (Root mean square of successive differences), HFn (High frequency normalized)) within the groups separately (see *Figure 2*).

We assumed that there would be differences between the groups in cardiovascular activity over time. However, comparing the groups, a repeated measures ANCOVA determined that there was no statistically significant difference between groups in HR and HRV (RMSSD, HFn) adjusted for chronic stress and 'participating in another measurement before'.

Based on a study by DiPietro et al. [20], it was assumed that HR would decrease with time, during the relaxation (T1-T2) as well as the recovery phase (T3-T4). A Wilcoxon signed-rank test for paired samples indicated that there was no significant difference between relaxation and recovery phase within each group in maternal HR. RMSSD was compared between phase T1 to T2 (delta) and T3 to T4 (delta). On average, RMSSD decreased from relaxation phase to recovery phase in the *guided imagery group*, which was statistically significant, $Z=-2.497$, $p=.013$, $r=0.75$. Maternal cardiovascular data is presented in *Table 2*. No significant differences in cardiovascular activity were found when comparing all three groups.

b. Maternal electrodermal response to relaxation procedures

As expected, women showed a significant decrease in skin conductance level over time (T1-T4) (see *Figure 3*). A repeated measures ANCOVA with a Greenhouse-Geisser correction revealed a slight decrease in SCL for the *resting group*, $F(1.325,13.255) = .152$, $p=.771$ and for the *guided imagery group*, $F(3,18) = 2.394$, $p= .127$ after adjusting for chronic stress and 'participating in another measurement before'. For *music group*, we found a significant decrease over time, $F(1.069, 5.345) = 10.385$, $p= .002$ after adjusting for chronic stress. The effect strength f according to Cohen (1988) is 0.63 and corresponds to a strong effect. This significant difference disappeared when we corrected for 'participating in another measurement before' with $F(1.021, 7.146) = 1.250$, $p=.301$.

A Wilcoxon test for paired samples showed that there was a significant time effect in SCL between relaxation and recovery phase in the *music group*, $Z= -2.666$, $p=.008$, $r= 0.88$, $n=9$ as well as the *resting group*, $Z= -2.981$, $p=.003$, $r=0.86$, $n=12$, and a trend for the *guided imagery group*, $Z= -1.955$, $p=.051$, $r=0.65$, $n=9$. Maternal skin conductance data is presented in *Table 3*.

No significant differences were found when comparing all three groups.

c. Maternal subjective response to relaxation procedures

Pregnancy-related distress was not significantly different between groups (see *Figure 5*). In general, women reported a significant decrease of stress symptoms. On the visual analogue scale, a significant time effect was found. We observed a decrease in maternal stress levels before and after the measurement for each group separately. A paired t-test determined a significant time effect in all three groups: *music group*: $t(11)=3.977$, $p= .002$, *guided imagery group*: $t(10)=4.363$, $p=.001$ and *resting group*: $t(11)=6.418$, $p=.001$.

In the POMS questionnaire, a Wilcoxon test for paired samples showed that, women in the *music group* reported a significant decrease over time in subscale depression/anxiety, $Z= -2.207$, $p=.027$, $r= 0.63$, $n=12$ and fatigue, $Z= -2.119$, $p=.034$, $r= 0.61$, $n=12$. In the *guided imagery group*, women reported a significant time effect in vigor, $Z= -2.090$, $p=.037$, $r= 0.63$, $n=11$. In the *resting group*, women reported a significant time effect in depression/anxiety, $Z= -2.758$, $p=.006$, $r= 0.79$, $n=12$, vigor, $Z= -2.312$, $p=.021$, $r= 0.66$, $n=12$ and hostility, $Z= -2.677$, $p=.007$, $r= 0.77$, $n=12$.

One-way ANCOVAs showed no significant differences in delta of mean VAS levels (Post-Pre) or for POMS delta (Post-Pre) for each subscale (depression/anxiety, fatigue, hostility, vigor) between groups after adjusting for chronic stress and 'participating in another measurement before'.

In an exploratory analysis step, we examined whether the relaxation effect changes with increasing gestational week. Based on a multiple linear regression analysis the effect of GA on VAS delta (Post-Pre) was significant, $F(2,35)=3.481$, $p=.029$. In the next step, we divided women in two groups based on their gestational age (Group 1: 29-34 GA, $n=21$; Group 2: 35-40 GA, $n=15$). A one-way ANOVA showed a significant difference between GA groups in VAS delta, $F(1,34)=4.971$, $p=.032$, $r=.146$, meaning women of Group 2 had lower mean VAS delta (mean: 0.86) compared to Group 1 (mean: 1.57) and relaxed slightly better. Women with higher gestational age (Group 2) had lower values in the Pre-rating which means they might have been somewhat less stressed (Mean (SD) Group 1: 2.33 (1.59); Group 2: 1.79 (1.72)) beforehand. The difference in the Pre-rating values between the groups was not significant, $F(1,34)=1.318$, $p=.259$.

5. Discussion

This study aimed to investigate the effect of three different relaxation interventions on stress related symptoms in the last trimester of pregnancy. This is the first study to compare three different acute mental-based relaxation techniques, as well as including a recovery phase without stimulation. We observed that on a physiological level mean maternal heart rate and mean maternal skin conductance level mainly decreased independent of intervention, while on a subjective level women showed lowered stress symptoms. Furthermore, we observed a significant difference - at least trendwise for the *guided imagery group* - between the relaxation and the recovery phase in skin conductance level in all groups independent of intervention. For maternal heart rate variability, a significant decrease was found in RMSSD between relaxation and recovery phase in *guided imagery group*. Gestational age was significantly associated with subjective ratings, indicating that women in later weeks (35-40th gestational week) relaxed less than women in earlier weeks of gestation (29-34th gestational week) based on self-reported stress level. However, we could not find any significant differences between active (*guided imagery group*) and passive (*music group, resting group*) mental-based interventions. The fact that we found no significant differences between the interventions highlights that quiet, comfortable sitting can be as effective as an active mental-based relaxation technique in the short term, on both objective and subjective relaxation parameters. Additionally, the significant differences between relaxation and recovery phase emphasize that duration of relaxation might play a role, with longer duration being more effective. These results are consistent with previous studies that also described an ongoing decrease in maternal heart rate after relaxation intervention in pregnant women.[46, 58]

In our study, we used different relaxation techniques, but explicitly considered the techniques separately to discover possible differences in effectiveness between acute active and acute passive relaxation techniques. In maternal heart rate, we found an increase for the *guided imagery group* despite the fact that women rated the guided imagery as relaxing. This may be due to the active relaxation stimulation. However, when comparing all participants, we could not find any significant differences between the groups. This is in line with a study by Teixeira et al. [37] who showed a greater decrease in MHR after active and passive relaxation for 58 women between 28-34 weeks of gestation in general. It is not in line with a study by Urech et al. [38], who reported significant differences between mental-based active (guided imagery), body-based active (progressive muscle relaxation) and passive relaxation (quiet sitting) intervention in 39 healthy pregnant women based on subjective ratings and cardiovascular activity. This inconsistency in reported results may come from the different duration of intervention because the relaxation intervention lasted for more than 60 minutes, which is twice as long as in our study.

Notably the effect of an increase in relaxation over time is in line with previous studies which reported an effect after at least 20 minutes of relaxation.[45, 59] It must be added that so far all studies that have investigated relaxation used interventions that lasted at least 20 minutes or longer with some of them being performed on a regular basis.

To our knowledge, this study is the first which showed a significant decrease in skin conductance level from relaxation to recovery after a short acute relaxation intervention. However, the difference was only significant in the passive relaxation groups (*music group, resting group*) and not in the active (*guided imagery group*). Recently, DiPietro et al. [45] reported a difference in skin conductance level between the relaxation and recovery phase, showing an increase. However, in this study a combined relaxation intervention of progressive muscle relaxation audio recorded, guided imagery and self-selected music was used. The baseline measurement lasted 18 minutes, the following stimulation intervention also 18 minutes and the following post-relaxation phase another 18 minutes. In addition, 41% of the participants were given an 18-minute pre-baseline (rest) to control for time effects. It should be noted that in the study of DiPietro et al. there was an interruption between relaxation and recovery where the lights were turned on and different questions were answered. This might explain why a significant increase in skin conductance level from baseline to relaxation and relaxation to recovery was found. Additionally, DiPietro et al. showed positive effects on subscales like physiological tension, physical assessment and cognitive tension (Physiological Tension and Physical Assessment subscales of Relaxation Inventory; Crist, Rickard, Prentice-Dunn, & Barker, 1989) which is in line with our results.

So far, our results can point out that an acute relaxation intervention during pregnancy without disturbance for 10 minutes can lead to a deeper relaxation during a following recovery phase (also lasting 10 minutes). The used interventions were effective in generating a subjective feeling of relaxation indicated by a significant decrease in subjective stress ratings post compared to pre relaxation. Our results indicate overall lower subjective stress symptoms after relaxation induction and a decrease in depressive and anxiety symptoms which is in line with the literature.[37–39, 60, 61] Notably, we included the maternal chronic stress level, since women participated with different stress levels, which was included as a covariate in the group comparisons.

As stated above, it is known that stress during pregnancy can have serious consequences for the child and the mother. These consequences can range from an increased risk of postpartum depression for the mother to an increased risk of obesity, mental illness for the child and delayed development of the fetal autonomic and central nervous systems. Consequently, the clinical interest in non-pharmaceutical prevention of stress and depression during and after pregnancy is high. The results of this study may be a starting point in helping to answer the question which relaxation interventions are particularly suitable for pregnant women in order to develop brief but effective relaxation programs for practical use.

Limitations

There are several limitations to this study. Nine out of 36 participating women had previously participated in another measurement at our center, with a break of up to 30 minutes afterwards, in contrast to the rest of the women who arrived at the center only shortly prior to the study. All participating women were at our center for the first time, so the women who participated in another measurement had a little more time to get used to the environment, and it can be assumed that they have been more relaxed. However, this was taken into account as a covariate in group comparisons. Further it must also be taken into account that almost all participating women had a high school diploma or higher. Previous studies have shown that women with a lower socio-economic status have a higher stress level per se, which can be due to financial worries, work overload, lack of family support etc.[3, 62–64] Further studies should include participants with more diverse socio-economic statuses. In addition, based on a study of Doberenz et al. [65], it is known that skin conductance levels are lower in sleep than when awake. During the measurement, five women fell asleep, which can lead to a

different baseline in skin conductance level and thus to a less significant decrease in SCL compared to women who were awake all the time.

6. Conclusion

The results of this study suggest that prenatal acute relaxation, even only applied once, can be a useful tool as a non-pharmacological approach in order to provide a higher state of maternal wellbeing during pregnancy. Improving maternal wellbeing and reducing stress in this way might mitigate potential negative effects of maternal stress on the fetus.

Considering the limitations, this study was the first to show that independent of acute active or acute passive relaxation, a relaxation intervention (music, guided imagery, resting) induces a reduction in maternal stress symptoms in the third trimester of pregnancy. Acute active and acute passive relaxation techniques implemented during the last trimester of pregnancy lead to changed maternal heart rate and skin conductance levels and lower subjective stress symptoms in all participating women.

Interestingly, the subjective psychological relaxation effect decreases with gestational age, with almost no decrease in stress level on the visual analogue scale for the group in later gestation. Notably, the results of this study show that there are differences between perceived subjective relaxation and the underlying physiological correlates. Despite some women rating the guided imagery as very relaxing, maternal heart rate increased over time in this group.

Clearly, more research is needed to specify non-pharmaceutical ways of relaxation during pregnancy. Therefore, follow-up studies will be necessary to investigate especially long-term effects of relaxation techniques, both on the subjective and physiological level for the mother and the child.

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FIGURES

Figure 1. Study design: The measurement procedure was divided into three phases from baseline to relaxation and to recovery measurement. Headphones were placed at the beginning of T1 in all groups. Each phase was divided into five minute segments for analysis.

Figure 2. Maternal Heart Rate (MHR): Overview of baseline corrected MHR (bpm) over all time points: Resting group, (Guided) Imagery group, Music group and all groups in total.

Figure 3. Skin conductance level (SCL): Baseline corrected SCL (microsiemens) over all timepoints: Resting group, (Guided) Imagery group, Music Group and all groups in total.

Figure 4. Trier Inventory of Chronic Stress (TICS), Short Scale of Chronic Stress (SSCS): Overview of mean values in all groups: Music group, Guided Imagery Group, Resting group.

Figure 5. Prenatal Distress Questionnaire (PDQ), Scale of pregnancy-related distress: Overview of mean values in all groups: Music group, Guided Imagery Group, Resting group.

TABLES

Table 1. Baseline characteristics of participants in the groups: music (n=12), guided imagery (n=12) and resting (n=12) interventions and all groups in total (n=36).

Group	Gestational Age (GA) (mean) in weeks (SD)	Maternal Age (mean) in years (SD)	Primiparous/Multiparous
All groups (total)	33.56 (3.21)	30.86 (4.30)	26/10
Music Group	34.50 (3.15)	30.08 (3.85)	11/1
Guided Imagery Group	31.83 (3.13)	29.58 (5.09)	8/4
Resting Group	34.33 (2.87)	32.92 (3.34)	7/5

Table 2. Overview of maternal cardiovascular activity. All values are baseline corrected. Maternal Heart Rate (MHR), Root Mean Square of Successive Differences (RMSSD), High frequency normalized (HFn). T1-T2: Relaxation phase; T3-T4: Silence phase.

Overview of maternal cardiovascular activity													
Intervention		MHR (T1)	MHR (T2)	MHR (T3)	MHR (T4)	RMSSD (T1)	RMSSD (T2)	RMSSD (T3)	RMSSD (T4)	HFn (T1)	HFn (T2)	HFn (T3)	HFn (T4)
Music Group	Mean	-1.66	-.86	-2.33	-2.48	5.19	7.42	8.70	7.50	.35	.33	.27	.33
	Standard error	.90	.89	.88	1.63	3.96	4.58	3.90	3.45	.05	.06	.04	.05
	Standard deviation	3.12	2.96	2.90	5.63	13.71	15.87	13.53	11.44	.19	.19	.15	.16
	N	12	11	11	12	12	12	12	11	12	12	12	12
Guided Imagery Group	Mean	-3.14	-3.90	-1.87	-1.40	4.67	9.48	2.61	-.39	.47	.41	.48	.41
	Standard error	.74	1.12	.55	.91	1.21	3.13	.77	1.57	.04	.06	.06	.00
	Standard deviation	2.45	3.70	1.81	3.03	4.03	10.38	2.43	5.22	.15	.20	.18	.01
	N	11	11	11	11	11	11	10	11	11	11	11	7
Resting Group	Mean	-1.09	-2.25	-2.44	-2.58	-1.05	6.89	1.40	9.92	59.40	50.70	54.22	52.88
	Standard error	.72	1.68	.97	1.24	3.16	6.83	1.95	7.49	6.63	6.79	6.02	6.43
	Standard deviation	2.48	5.83	3.38	4.31	9.98	23.67	6.47	25.95	22.97	23.52	20.84	22.28
	N	12	12	12	12	10	12	11	12	12	12	12	12
All Groups	Mean	-1.93	-2.33	-2.22	-2.17	3.13 ^a	7.88	4.42	5.80	20.63	17.63	18.83	20.69
	Standard error	.47	.76	.47	.74	1.79	2.91	1.64	2.93	5.29	4.68	4.82	5.26
	Standard deviation	2.77	4.43	2.72	4.39	10.27	17.20	9.42	17.10	31.27	27.68	28.52	29.30
	N	35	34	34	35	33	35	33	34	35	35	35	31

Table 3. Overview of all physiological parameters for Music Group, Guided Imagery Group, Resting Group and all groups in total. All values are baseline corrected.

Overview of maternal skin conductance levels					
Intervention		SCL (T1)	SCL (T2)	SCL (T3)	SCL (T4)
Music Group	<i>Mean</i>	1.03	.12	.01	-.04
	<i>Standard error</i>	.26	.07	.04	.05
	<i>Standard deviation</i>	.89	.21	.14	.17
	<i>N</i>	12	10	10	10
Guided Imagery Group	<i>Mean</i>	1.57	-.22	.20	-.72
	<i>Standard error</i>	.41	.26	.24	.46
	<i>Standard deviation</i>	1.28	.83	.73	1.46
	<i>N</i>	10	10	9	10
Resting Group	<i>Mean</i>	1.32	.12	-.08	-.14
	<i>Standard error</i>	.39	.18	.13	.17
	<i>Standard deviation</i>	1.36	.61	.45	.58
	<i>N</i>	12	12	12	12
All Groups	<i>Mean</i>	1.29	.01	.03	-.29
	<i>Standard error</i>	.20	.11	.09	.16
	<i>Standard deviation</i>	1.17	.61	.49	.92
	<i>N</i>	34	32	31	32

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