HEALTH BENEFITS FOR THE MOTHER AND CHILD FROM MUSIC INTERVENTION IN PREGNANCY
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Introduction: Pregnant women are especially vulnerable to anxiety disorders, but stress and anxiety have been associated with premature and low birth weight babies, presumably because of fetus overexposure to glucocorticoids of maternal origin. Antenatal stress also seems to have long-term effects upon the newborn development and adult health. Medication carries risks to the expectant mother, thus the efficacy of non-pharmacological interventions should be investigated.

Objective: This chapter reviews relevant literature on the negative effects of mother’s anxiety upon the fetus and, because music has long been suggested to be a valid method of relaxation, studies regarding the effect of music listening in the fetus and in adults are also reviewed. We present results of our own study on the impact of three methods of relaxation upon pregnant women awaiting amniocentesis.

Methods: Women (n=184) were randomly divided into three groups and subjected to a 30 min intervention: (1) listening to relaxing music, (2) sitting and reading magazines, and (3) sitting in the waiting-room. Before and after the intervention, women completed the Spielberger’s self-rating anxiety questionnaire and provided blood samples for cortisol (C) and testosterone (T). The groups were compared regarding change in C and T levels and in anxiety.

Results: We found a significant correlation between C in maternal plasma and amniotic fluid. Maternal C and state anxiety were also correlated. The greater decreases in plasma C occurred in the music group, followed by the magazine group, and differences between interventions were statistically significant. Women in the music group also decreased T and had the greater decreases in state anxiety.

Conclusion: Pregnant women might benefit from the routine practice of relaxation in clinical settings or at home. Such practice should diminish the likelihood of fetus exposure to high levels of stress hormones, mainly cortisol, with health benefits for child postnatal development and for adulthood. Music appears to be an effective and inexpensive way to lower anxiety levels in a short period of time, a benefit that has been shown to correlate with decreases in plasma and amniotic cortisol and plasma testosterone. We propose that routine use of relaxing music should thus be considered before stressful clinical events and as a domestic routine during pregnancy.

Key words: antenatal stress, pregnancy, relaxation, music, hormones
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ABSTRACT

Pregnant women are especially vulnerable to anxiety disorders, but stress and anxiety have been associated with premature and low birth weight babies, presumably because of fetus overexposure to glucocorticoids of maternal origin. Antenatal stress also seems to have long-term effects upon the newborn development and adult health. Medication for stress is a possible solution but it carries risks to the expectant mother, thus the efficacy of non-pharmacological interventions should be investigated. This chapter reviews relevant literature on the negative effects of mother’s anxiety upon the fetus and, because music has long been suggested to be a valid method of relaxation, studies regarding the effect of music listening in the fetus and in adults are also reviewed. We present results of our own study on the impact of three methods of relaxation upon pregnant women awaiting amniocentesis. The women (n=184) were randomly divided into three groups and each was subjected to a 30 min intervention: (1) listening to relaxing music, (2) sitting and reading magazines, and (3) sitting in the waiting-room. Before and after the intervention, women completed the Spielberger’s self-rating anxiety questionnaire and provided blood samples for cortisol (C) and testosterone (T). The groups were then compared regarding change in C and T levels and in anxiety. We found a significant correlation between C in maternal plasma and in the amniotic fluid. Maternal C and state anxiety were also correlated. The greater decreases in plasma C occurred in the music group, followed by the magazine group, and differences between interventions were statistically significant. Women in the music group also decreased T and had the greater decreases in state anxiety. Pregnant women might benefit from the routine practice of relaxation in clinical settings or at home. Such practice should diminish the likelihood of exposure of the fetus to high levels of stress hormones, mainly represented by cortisol, with health benefits for child postnatal development and for adulthood. Music appears to be an effective and inexpensive way to lower anxiety levels in a relatively short period of time, a benefit that has been shown to correlate with decreases in plasma and amniotic cortisol and plasma testosterone. We propose that the routine use of relaxing music should thus be considered before stressful clinical events and as a domestic routine during pregnancy.

1. INTRODUCTION

Anxiety or stress disorders with diverse severity affect about 20% of all pregnancies (Alder et al 2011). Although most fetuses are not affected, it is known that chronic or acute stress is likely associated with increased risk of prematurity and low birth weight of the newborn infant (Morken et al 2006, Zhu et al 2010). These children also seem to have higher risk of developing attention deficit-hyperactivity disorder (ADHD) and associated disorders (Thapar et al 2012), as well as other mental disturbances (Huizink et al 2004). Recent research suggests that, since ADHD is more common in the progeny of mothers who are anxious or stressed, the increased impulsivity and explorative behavior in these children may be an adapting mechanism to live in a stressful or dangerous environment (Glover 2011). Yet the external world is not always that defying and child unfitness
may overcome. Maternal anxiety seems to have more negative effects on children than does maternal depression, as the former associates with lower cognitive results and increased risks of mental health in the descendants (O’Connor et al 2002, Bergman et al 2007). This problem may reach public health proportions in modern societies, rendering interventions to improve maternal psychological well-being a very important concern from the beginning of pregnancy (Van den Bergh et al 2005, Fink et al 2011).

Maternal medication for psychological problems is potentially associated with collateral effects in the mother and the fetus, as antidepressants and benzodiazepines are known to get across the placenta barrier (Hendrick et al 2003), explaining why future mothers are frequently reluctant to take them. Collateral effects may be exacerbated in a context of increased maternal humor sensitivity that characterizes normal pregnancy and the postnatal period (Lokuge et al 2011). Such sensitivity is caused by increased serotonin availability, due to the usual high levels of estrogens that characterize pregnancy. Animal studies also show that antidepressants, like fluoxetine, interfere differently with individual’s cortisol levels and behavior, depending on previous presence or absence of antenatal stress (Pawluski et al 2012). Prevention and therapy in pregnant women have thus implications at various levels, being no wonder that non-pharmacological interventions have been increasingly elected as important means of reducing stress and anxiety in pregnancy (Cunningham and Zayas 2002, Field et al 2003, Lee et al 2004, Van den Bergh et al 2005).

Anxiety has been shown to respond well to behavior therapies and several technics are available with proven efficacy (Marc et al 2011). Psychotherapy, hypnotherapy, massage, yoga, guided imagery and music listening are all well tested methods (Cunningham and Zayas 2002, Narendran et al 2005, Chang et al 2008, Maharana et al 2009, Field et al 2009, 2010, Gedde-Dahl and Fors 2012), with music listening being probably the most accessible way of relaxing in all social groups, including the ones of lower financial incomes.

1.1. Perinatal Exposure to Sound and Music

Sound is defined as a physical sensation that stimulates our ears through longitudinal waves detected by earing structures which integrate ear physiology with brain psychology (Giancoli 1998). The incoming sound information received from the temporal cortex and the auditory system, interconnect in the amygdala, a small structure in the middle of the brain and part of the hippocampus that is considered the center of emotions. The amygdala also receives connections from the prefrontal cortex, where information is discriminated, and from somatosensory areas like earing and touch (Altenmüller 2004). The mechanisms underlying the effect of music seem to involve the interaction of the earing (peripheral) and the cortical central systems with the autonomous nervous system (Collinge 1998, Crowe 2004). Relaxation occurs through parasympathetic action on the heart and breathing rate, and on blood pressure and oxygen consumption (Schneck et al 2006).

Sound velocity changes with the elasticity and density of the materials crossed: the transmission of acoustic waves is faster in liquids and increases with temperature (Giancoli 1998). The fetus inhabits a fluid environment and sound arrive mainly either through bone transmission through the mother, or from outside through the abdominal wall, arriving almost simultaneously to both ears (Jardri et al 2008). Human audition responds to sound frequencies from 20 to 20,000 Hz (1 Hz= 1 cycle per second) (Giancoli 1998), being the low frequencies the first to be detected in the womb. It is known since long that by the end of pregnancy human fetus can detect sounds originating from outside their mothers (Querleu et al 1988). In adults, audition is associated with bilateral cortical and earing structures activation, crossing from one side to the other of the brain, through a small central structure called olive (Werner 1998). By the end of pregnancy all the axons are present in the fetus (Kostović and Jovanov-Milošević 2006) but myelination is incomplete, which probably explains why above 33 weeks the fetus already shows high discrimination processing but, unlike adults, only with unilateral activation (Jardri et al 2008). Nevertheless, prenatal exposure to music has been
associated with improved fetus brain development, apparently promoting better neonatal spatial learning and anticipating motor development related to sitting and walking (Chen et al 1994).

Experiments with rodents have shown that maternal antenatal stress is associated with an increased production of corticosterone (the equivalent of cortisol in humans, a well-known stress hormone) which is known to cross the brain barrier (Zarrow et al 1970). Animals whose mothers had been submitted to noise while pregnant, showed reduced neurogenesis in the hippocampus, later exhibiting problems in learning and memory. On the contrary, listening to music during pregnancy improved hippocampus neurogenesis and the learning of tasks implying spatial capabilities (Kim et al 2006). Also in chicken exposed to music before egg outbreak, investigators found increased protein expression in the synapsis of their auditory nuclei and increased number of neurons in the prosencephalus area associated with audition (Alladi et al 2002, Panicker et al 2002). Other studies have shown that noise associates with higher risk of still birth, central nervous system anomalies, disabled social behaviors and immunity deficiencies in the descendants (Sobrian et al 1997, Kay et al 1998) whereas music during pregnancy may facilitate offspring brain growth and development (Arabin 2002).

In humans, fetal audition is essential for future speech development since speech is dependent on the capacity of cognitive sound discrimination and involves the formation of axons that are specific for that purpose (Draganova et al 2005). Although brain myelination is completed only some years after birth, the middle ear structures are developed and functional by as early as 20 weeks of gestation (Tucci 1996) and audition is practically complete before birth (Graven and Browne 2008). Pepper and Shahidullad (1994) found motor responses to pure low frequency sounds in fetus with only 19 weeks (500Hz) and above 33 weeks all fetus responded to high frequency sounds (1000 to 3000 Hz). Cognition requires myelination and the formation of synapses after birth (Courchesne 1990), but the frequent earing of sounds during pregnancy, like the ones produced by internal organs and the mother’s voice, have an important role in the process. The fetus seems to keep memories of them, leading some authors to talk about “fetal learning” (Kisilevsky and Hains 2010).

Stress can interfere with the above described processes as individuals having growth restriction also show a high rate of language disabilities (Kisilevsky and Davis 2007). Human newborns from depressed mothers were less responsive to voices and had a delayed heart rate deceleration in response to music, as compared to controls, probably due to less attention or slower information processing (Field et al 2009). The noise in Neonatal Intensive Care Units (NICUs) is a cause of stress that may have harmful consequences for the newborn, mainly in premature babies, in whom hearing is still under development. It may lead to sleep disturbances and physiologic instability: alterations in sleep-wake states, hypoxemia, tachycardia, hypertension, apnea and, in the long run, hearing deficiencies or even loss, poor developmental outcome including problems in speech and language (Brown 2009, Altuncu et al 2009, Wachman and Lahav 2011, McMahon et al 2012). The introduction of environmental music on a regular basis in the NICU showed positive effects in oxygen saturation, heart and breathing rate in newborns (Field et al 2006), possibly through the attenuation of environmental noise. Infants exposed to recording of maternal voice experienced improved short-term outcomes compared to infants receiving routine NICU care (Krueger et al 2010). McMahon et al (2012) found that exposure of preterm infants to vocal music was associated with increased oxygen saturation, improvement in weight gain and shorter hospital stay and the effect of vocal music increased if the singer was the mother. The application of music to premature newborns has thus shown promising results but further studies are needed. Authors like Standley (2002) state that auditory stimulation should be limited to babies older than 28 weeks gestation, cautioning professionals against the use of music in ways of unknown clinical value, such as live instrumental performances in the NICU, radio stations, and toys generating music (Standley 2002).

1.2. Adults and Music in Clinical Settings
Music is an elaborated form of environmental sound (Fitch 2006) that stimulates imagination leading to autonomic responses of the thalamus and other limbic system structures that are involved in brain interconnections which determine feelings and emotions (Watkins 1997). The feeling of pleasure detected through the right hemisphere stimulates the release of endorphins by the pituitary, leading to a reduction in circulating catecholamines (Sidorenko 2000). Various controlled experiments also provided evidence for a positive effect of music on adults. After listening to music, depressed teenagers showed lower saliva cortisol and electroencephalographic attenuated activity in the right prefrontal cortex (Field et al 1998). In adults, music listening was associated with lower plasma cortisol (Vanderark and Ely 1993) and saliva cortisol decreased more quickly when adults listened to music after being submitted to stress (Khalfa et al 2003).

Music has been suggested to be a valid treatment method since Pitagoras (Sidorenko 2000). In our society, it has long been used in clinical settings and its popularity has been increasing. Holistic medicine sees it as a way of creating harmony through interaction of body and mind (Fitch 2006) being an effective therapeutic option (Olson 1998) that neutralizes emotions, increases stress threshold and facilitates relaxation (Field et al 1998, Sidorenko 2000). In several clinical settings for invasive examinations, like colposcopy, music reduced anxiety and pain perception (Chan et al 2003, Galaal et al 2012), and associated with lower saliva cortisol (Uedo et al 2004). In post-operative situations it was associated with quicker recovery and less pain perception (Ebnesahidi and Mohseni 2008), or reduced anxiety (Johnson et al 2012). Listening to music may enhance relaxation by providing a distraction from a focus of awareness, such as an existing stress or physical pain source (Davis et al. 1999; Evans 2002; Kwekkeboom 2003). Distraction may combine with the physiological effects of listening (for reviews see Schneck and Berger 2006; Krout 2007) being beneficial to the listener by enhancing the relaxation process. In short, music has shown to be an excellent non pharmacological mean of relaxation, easy to implement in several settings, either clinical or at home. These studies suggest that well-chosen music could be an excellent option to promote health and well-being during pregnancy.

Personal individual aspects may influence the final results of music listening, leading to different degrees of efficiency (Bradshaw et al 2011). The listener preference when electing the music to be heard seems to influence the effects of music (Bradt 1997), with the individual choice reinforcing the relaxing effect (Watkins 1997). The importance of the type of music has been shown through different studies. The effect of instrumental music versus lyrics with voices has been under some controversy with a few authors claiming that music with words may trigger emotions and memories that may be contra productive for relaxation (Chang et al 2008). Agitated music in a group of gymnasts associated with increased cortisol levels (Brownley et al 1995), calm music in pre-operative care was more efficient than oral midazolam in reducing anxiety and after surgery associated with significant reduction in cortisol levels and cardiovascular and respiratory stabilization (Trappe 2012). Some types of music specially conceived to induce resonance and relaxation have shown efficacy in reducing anxiety in pregnancy, increasing pain threshold and reducing analgesic needs, with obvious benefits to the fetus (Sidorenko 2000). Music changes the interaction between the thalamus and the autonomous nervous system, as reflected in autonomous functions like heart rate or blood pressure (Krout 2007). Current evidence suggests that all stress related processes in pregnant women can benefit from relaxing music interventions, which trigger interconnections of psycho physiological systems that act through hormonal production and result in benefits for mothers and child’s developing brain (Krout 2007).

1.3. Music and Pregnancy

Normal pregnancy is associated with increased average levels of plasma cortisol (Mastorakos and Ilias 2003), but physiologic mechanisms of defense against high levels of glucocorticoids, like cortisol, are also present. The inner balance that develops may be disrupted and the most frequent cause of disruption is anxiety, a complex psychobiological process that pregnant women experience frequently (Spielberger et al 1970). Furthermore, stress or anxiety during pregnancy is a risk factor
for depression after delivery, which seem to affect 10-20% of all recent mothers (Evans et al 2001, Bennett et al 2004). Increased anxiety levels may continue during the postnatal period, mainly in those women exhibiting a high trait anxiety score as evaluated, for example, by standard psychological questionnaires (Leithner et al 2004, Sarkar 2006).

Music, on the contrary, has been shown to prevent negative outcomes in different settings. For example, listening to preselected music during labor and delivery, showed association with significant reduction in anxiety and pain (Clark et al 1981). Listening to music during cesarean section also associated with anxiety reduction (Chang and Chen 2005). In high risk pregnancies held at the hospital, music reduced stress perception by the women (Sidorenko 2000), and listening to preselected music daily for 30 min reduced stress and anxiety scores in psychological questionnaires (Chang et al 2008).

1.4. Amniocentesis as an Anxiogenic Stressor

Different levels of stress or repeated episodes of anxiety during pregnancy may have adverse effects on the pregnancy outcome. Gutteling et al (2005), for example, reported that the mother’s anxiety evaluated at 16 weeks of pregnancy (based on daily hassles and fear about pregnancy and delivery) associated with higher cortisol response in their children at 5 years of age by the time of vaccination. Amniocentesis is a common invasive procedure to access fetal karyotyping which can be viewed as a non-experimental paradigm of an acute anxiogenic stressor (Ng et al 2004, Csaba et al 2006). Anxiety due to amniocentesis is related to feelings of apprehension, fear of abortion and pain, and fear for the results. Women awaiting amniocentesis have increased scores in questionnaires where they are asked to self-rate their own anxiety, like the Spielberger State and Trait Anxiety Inventory (STAI-S and STAI-T) (Spielberger 1983). Furthermore, their anxiety scores showed significant positive correlation with their cortisol levels (Sarkar et al 2008).

As an isolated episode of induced anxiety, amniocentesis could hardly be harmful, but sequences of daily stressful episodes will add distress to the mother throughout pregnancy and amniocentesis is a metaphor for one such episode. Several methods used for relaxation in clinical settings have shown some efficacy in relaxing women awaiting amniocentesis (Alder et al 2011, Teixeira et al 2005, Chuang et al 2011, Fink et al 2011, Narendran et al 2005, Chang and Chen 2005), however, only commercial music can be easily applied in clinical settings where medical examinations and invasive proceedings take place. Other forms of music, including those specially conceived for children and pregnant women (Chang et al 2008) or regular calm bits (Gadberry 2011), would not be adequate in medical offices since waiting rooms are populated with diverse occupiers and not only pregnant women.

2. A STUDY ON THE IMPACT OF RELAXATION UPON WOMEN AWAITING AMNIOCENTESIS

We have conducted a study aimed at investigating the impact of a short-term (30 min) relaxing intervention upon pregnant women in the imminence of amniocentesis (Ventura et al 2012). The impact was evaluated with both psychological and hormonal variables and it compared three different forms of relaxation, one of these being music listening. We wished to evaluate this accessible non-pharmacological form of reducing anxiety in pregnant women in comparison with other accessible interventions.

Women (n=184) were randomly assigned to three groups of relaxation. Those in the first group (n=57) sat comfortably in the waiting-room, and tried to relax in the company of a relative for 30 min. Women in the second group (n=57) sat reading a decoration magazine with contents unrelated to maternity or children. Finally, in the third group (n=70), women comfortably listened to music,
either with 15W loudspeakers or headphones, at a volume level regulated by the participant. Because of the usual presence of environmental noise, the results with headphones were later compared with those of loudspeakers, however, like previous authors (Tsivian et al 2012), we did not find evidence for differences.

The music style considered relaxing is different depending on personal experience, age, social and economic status (Dunn 2004, Krout 2007), thus the participants were invited to choose the music of their like from a set of four possible styles, including modern instrumental (chosen by n=15 women), vocal lyrics (n=18), jazz with lyrics (n=26), and classical music (n=11). The women allocated to the music group first listened to a 3 min demonstration CD with the four available styles of music, picked one and then proceeded for the full 30 min session.

Regardless of style, all tracks were commercial and relatively well known, which would make them acceptable in most clinical environments. The duration of the intervention is also important. We chose 30 min because it would be easier to implement as part of routine clinical procedures and because a too long exposure in a non-familiar environment could be counter-productive. However, for domestic purposes the time spent relaxing, as well as the music selection, can be more dependent on the women’s choice, within reasonable limits.

We have hypothesized that the 30 min relaxation would benefit the women through anxiety reduction, decrease in blood pressure and heart rate, and decrease in the levels of cortisol, a well-known stress hormone, and eventually a change in testosterone. Testosterone is a key hormone in processes organizing central nervous structures and the cardiovascular system at critical periods of fetus development, when the environment surrounding the fetus is most important (Vermeersch et al 2008). The induced structural variations acquired in uterus translate later in life into different behavioral aspects and cardiovascular risk (Sanders et al 2002, Barker et al 2002). Testosterone after birth activates its own receptors, which also translates into behavioral and physiological responses.

Since cortisol levels are known to be higher and less responsive to stress in the morning (Sarkar et al 2006), the experiment was conducted with women awaiting amniocentesis in the morning (8:30-12:00h, n= 101) and in the afternoon (12:00-15:00h, n=83). All women were asked to fill in a STAI-S (how do you fill right now?) and a STAI-T (how do you usually feel?) self-rating questionnaire of anxiety before and after the relaxation intervention (Ventura et al 2012). Physiological variables (heart rate, blood pressure) were also measured and blood samples were collected before and after relaxation, in order to evaluate the changes in hormone levels (cortisol and testosterone).

### 2.1. Results

The mean heart rate decreased in all three relaxation groups (usually 4 to 6 beats) and so did the mean blood pressure, but the decreases were not significantly greater in those who listened to music as compared to reading the magazine or sitting in the waiting room. A different picture emerged regarding changes in state anxiety, cortisol, and testosterone.

STAI scores usually ranged between 20 and 60 points (scale 20-80). The state of anxiety (STAI-S) decreased on average 8.2 points in the music group, which was statistically greater than decreases of 5.7 and 4.1 points (Figure 1), respectively, in the magazine and in the waiting room groups (ANOVA p=0.004). On average, younger mothers with lower gestational ages were the most anxious before relaxation. This is in agreement with the claim that, as pregnancy advances, the psychological response to stress becomes progressively attenuated (Glynn et al 2004). These more anxious women were also the ones that exhibited greater decreases within all groups and music appeared to be particularly effective at diminishing their anxiety. We have reexamined the comparison between intervention groups after removing the effect of the initial STAI–S score by analysis of covariance. The results remained significantly different between groups, with music remaining the most effective intervention.
The concentration of cortisol in plasma before relaxation varied between 179 and 1334 nmol/L with an average of 578 nmol/L (stdev=216). Cortisol and state anxiety (STAI-S) were correlated in the afternoon ($r=0.22$; $p<0.05$) and multiple regression showed that the major predictor of the level of maternal cortisol was time of the day (higher in the morning, lower in the afternoon) followed by state anxiety, hinting why cortisol is deemed a stress hormone. In the amniotic fluid, cortisol was about 30 times less concentrated than in the mother’s plasma but correlated with it, depending on gestational age ($r=0.27$ and $r=0.46$, at less than or more than 17 weeks gestation, respectively; all correlations being statistically significant). This is indicative of the transfer of cortisol from the mother to the amniotic fluid across the placenta, and hints for a likely mechanism of the increased exposition of the fetus to maternally derived glucocorticoids when the latter are raised at times of stress.

After relaxation, cortisol decreased on average -60.6 nmol/L in women who listened to music, decreased -51.2 in those reading magazines, and increased on average 7.9 nmol/L in women in the waiting room (Figure 1), translating into a significant difference between groups (ANOVA $p=0.004$). Women with higher cortisol levels before the intervention were also the ones that tended to decrease the most during the 30 min relaxation. Multiple regression confirmed these findings, indicating that initial level of cortisol, type of relaxing intervention, and time of the day, in this order, were the most important predictors of cortisol change. Altogether these variables accounted for a significant 13.4% ($p < 0.001$) of variation in cortisol change.

![Figure 1. Variation in state anxiety score (STAI-S), plasmatic cortisol (nmol/L) and testosterone (nmol/L), in women subject to three types of relaxing intervention (Mus=music, Mag=read magazine, W=waiting room). Vertical bars are 95% confidence intervals around mean variation. Dashed horizontal lines signal zero variation and all values below it indicate a decrease following the intervention.](image)

As for testosterone, the average levels were 1.65 nmol/L (st dev=0.87) before relaxation and decreased -0.11 nmol/L in the magazine and -0.08 nmol/L in the music group, increasing 0.06 nmol/L in the waiting room (Figure 1). The most prominent characteristic in the variation of testosterone following relaxation was its strong correlation with the variation in cortisol ($r=0.53$, $p<0.001$). Reading and music triggered a decrease in testosterone in only 30 min. Since in women testosterone is mainly produced at the ovary (gonads), our results suggest that this relaxing period was enough to deactivate the stress hormonal axis response (hypothalamus-pituitary-adrenal-gonadal) that ultimately affects the gonads. This idea is also supported by the highly correlated variation of cortisol and testosterone. Unlike long lasting stress, that lowers the gonadal function, acute stress in rodents and humans activates a small increase in testosterone production (Rivier and Rivest 1991) and our results indicate that acute relaxation reverses this effect.

There were no significant differences between the groups of intervention regarding changes in cortisol or testosterone in the amniotic fluid, which is probably due to the short period of intervention and also the low concentration of hormones in the amniotic fluid. To detect possible differences between groups in such low concentrations would probably require a much larger sample.
3. CONCLUSION

Pregnant women would benefit from the routine practice of relaxation, especially in the imminence of stressful events taking place in clinical settings or domestic life. Such practice should diminish the likelihood of exposure of the fetus to high levels of glucocorticoids, well-known stress hormones mainly represented by cortisol, with health benefits for child postnatal development and adulthood. Music appears to be a useful and inexpensive way to lower anxiety levels in a relatively short period of time, a benefit that has been shown to correlate with decreases in maternal plasma and amniotic fluid cortisol. We propose that the routine use of relaxing music should thus be considered before stressful clinical events and as a domestic routine during pregnancy. Testosterone also decreased with music, although reading was more effective at lowering this hormone. The variation of cortisol and testosterone were highly correlated, and this interesting result points to an additional benefit for pregnant women, that needs to be confirmed in further studies.

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