

## Music Therapy and Music Medicine during Antenatal Period: Mechanisms and Evidence of Effects on Maternal and Fetal Health

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### ABSTRACT

Music-based interventions, which include music therapy, music medicine, and other music-based interventions, are increasingly becoming popular in general population and health care professionals globally. In India, music and sounds have been used for health benefits since ancient time, but evidence-based music therapy as an allied health science is still in developing stage. Uniqueness of use of music-based interventions during antenatal care is due to their effects on both the expecting mother and the developing fetus; recent experiments related to effects of antenatal exposure of sounds and music on fetal neurodevelopment have particularly revealed interesting findings. The present article aims to discuss types of music-based interventions during antenatal period, their maternal and fetal effects and their possible mechanisms. Detailed description of music/music-based interventions and use of music-based interventions during labor, during post-natal period and for neonates/infants are not discussed.

**Key words:** music-based intervention, music medicine, music therapy, fetal medicine, pregnancy, fetal development

Music and sounds have been used for therapeutic purposes since time immemorial. Important references related to effects of music on human physiology, psychology, and spirituality are found in various Indian scriptures and texts such as the Vedas, Gandharvatattva, Brhaddesi, and Sangitaratnakara as well as in literature of other ancient civilizations [1]. However, it was in 1940s when “music therapy” started to develop as a profession based on scientific research in Western countries and the last four decades have seen an exponential increase in research in music therapy globally.

Among various applications of music-based interventions, antenatal applications stand unique, because their beneficial effects are not only limited to health and well-being of prospective mother, but also extend to the developing fetus. Again, concept of Garbha Sanskara (literally meaning “education in womb”) traces its roots in ancient traditions in India and several Garbha Sanskara practices use music and sounds [1, 2], but when antenatal music-based interventions are seen as scientific practices, it is important to know evidence and mechanisms. Not only that the scientific approach would make these

interventions more rational, but it is also more likely to facilitate integration of such interventions into obstetric practice.

This article aims to discuss applications of music-based interventions during antenatal period with emphasis on its effects on both the mother and the fetus with explanation of proven or possible mechanisms. Music-based interventions during labor or surgical delivery and those during post-natal period (for mother) or neonatal period (for the newborn) are not discussed in this article.

### MUSIC-BASED INTERVENTIONS IN HEALTH CARE: TYPES AND DEFINITIONS

Music-based interventions are broadly classified into music therapy, music medicine, and other music-based interventions. American Music Therapy Association (AMTA) defines “music therapy” as “clinical and evidence-based use of music interventions to accomplish individualized goals within a therapeutic relationship by a

credentialed professional who has completed an approved music therapy program” [3], whereas “music medicine” refers to passive listening to pre-recorded music, which is usually “prescribed” by health care professionals who are not trained music therapists. This is an important distinction because music therapists are trained to evaluate patients from perspective of music therapy and to use various active and passive music therapy techniques, while such components are missing in music medicine approach. It is also important to differentiate music therapy from music medicine because there are several examples in scientific literature in which studies evaluating effects of passive listening to music are published as “music therapy” studies [4]. Other music-based interventions include interventions that use music but do not qualify for music therapy or music medicine [5].

### **EFFECTS OF ANTENATAL MUSIC-BASED INTERVENTIONS ON MATERNAL HEALTH**

Effects of music on human beings are multidimensional. Music therapy is known to affect both human physiology and psychology. It also affects social health positively and possibly, spiritual health. Listening to music during antenatal period has shown to reduce maternal stress and anxiety, to reduce maternal depression, to improve maternal mood, and to enhance maternal-fetal relationship [6]. Interestingly, music exposure during antenatal period, especially during third trimester has also shown to reduce labor pain and to facilitate delivery process [6, 7].

As mentioned above, music therapy goes much more beyond passive listening to music and includes several techniques practiced by trained music therapists that aim at improved physiology and psychology of the pregnant women. Therefore, in addition to above mentioned effects, music therapy approaches have also shown to facilitate cognitive adjustment, to facilitate regulation of mood and emotions, to improve self-esteem and self-efficacy, to enhance positive attitude towards the new responsibilities, to improve social interactions, to facilitate expression of feelings, and to improve overall maternal wellbeing [8].

### **EFFECTS OF ANTENATAL MUSIC-BASED INTERVENTIONS ON FETAL HEALTH AND DEVELOPMENT**

Description of development of fetal auditory system, including auditory cortex, is beyond scope of this article, but in order to form basis for fetus-directed antenatal music-based interventions, it is important to note that human fetus consistently responds to sounds in the

mother’s environment by 25-28 weeks of gestational age and that the fetal responses to music developmentally mature with increasing gestational age. For the external sounds to reach internal ears of the fetus, they must pass through fluids and tissues surrounding fetal head. Bone conduction through skull bones is the primary route. Low-frequency sounds are more reachable to internal ears of the fetus than high-frequency sounds and the fetus-in-utero can easily hear sounds with frequency less than 500 Hz that are produced at intensity which is comfortably loud for the mother [9]. Interested readers are suggested to read some selected references [9-12].

Effects of music on neurodevelopment of the fetus are interesting. A randomized controlled trial has shown that regular antenatal music exposure from 20 weeks of gestation onwards of primigravida mothers significantly improves neonatal behavior in their appropriate-for-date neonates as compared to neonates born to mothers who had received only standard antenatal care [13]. The neonates born to “music group” of mothers significantly performed better on five of seven clusters of Brazelton Neonatal Behavioral Assessment Scale, showing better maturation (functioning) of their central nervous systems during the fetal development as compared to the control group.

Another study has shown that brains of infants, who were exposed to melodies during the last trimester of pregnancy, exhibit stronger event-related potentials (ERPs), and their effect persists at least up to four months of age [14]. Another study has shown that after controlled exposure of a descending piano melody to near-term fetuses for three weeks, exposure to the same piano melody at post-natal age of one month evokes significantly larger cardiac decelerations as compared to one-month-old infants who had not been exposed to the melody during fetal life [15]. Effects on fetal neurodevelopment, fetal memory, and fetal learning are important effects of music-based interventions during antenatal period and are highly interlinked, as is being discussed in subsequent paragraphs. Fetal musical experiences may also affect speech perception and language acquisition during post-natal life [16] and antenatal music training may reduce autistic-like behaviours at three years of age [17].

### **MECHANISMS TO SHOW EFFECTS OF MUSIC-BASED INTERVENTIONS ON PREGNANT MOTHERS**

1. **Stress reduction:** As far as stress is concerned, pregnant mothers form a special population, because they are vulnerable not only to “general” stressors applicable to

general population but also to pregnancy-specific stress due to concern about pregnancy, delivery, and the new responsibilities. Psychophysiology of stress is complex and involves maternal endocrine, nervous, and immune systems. Stress reduction during pregnancy is an important component of antenatal care because prenatal stress is associated with increased risk of pregnancy complications such as pre-eclampsia, gestational diabetes, pre-term labor, and pre-term delivery [18].

Music-based interventions, including both music therapy and music medicine, are known to reduce stress in not only pregnant women but in most groups of population. Music-based interventions reduce stress response by multiple mechanisms such as muscular relaxation, effects on autonomic nervous system, effects on HPA (hypothalamic-pituitary-adrenal) axis, facilitation of slow and deep breathing, pain reduction, distraction, influence on stress-related cognitive processes in brain, and emotional modulation [19].

**2. Reduction of anxiety and depression:** Anxiety and depression in pregnant women are associated with increased risk of pre-term delivery and other obstetric complications [20]. Music therapy is increasingly being used in treatment of anxiety and mood disorders in general population. A recent meta-analysis concluded that music-based intervention may reduce anxiety in pregnant women [21]. As per a recent review, [22] evaluating effectiveness of music interventions in treatment of depression, 26 out of 28 studies showed statistically significant reduction in depression levels. A few studies have shown effectiveness of music-based interventions to improve symptoms of depression in pregnant women [6, 8, 23, 24]. Interestingly, music-based intervention during pregnancy may also reduce symptoms and severity of post-natal depression [25].

Possible mechanisms to show therapeutic effects of music-based interventions in psychiatric disorders include alterations in physiological functions (such as heart rate, blood pressure, respiration, and muscle tone), relaxation response, predominance of parasympathetic nervous system over sympathetic nervous system, altered levels of neurotransmitters in central nervous system, decreased levels of stress hormones (cortisol, adrenocorticotropic hormone, and corticotropin-releasing hormone), and complex cascade of neurological events involving areas of brain related to cognition, emotions, imagination, memory, mood and basic instincts [26]. Psychosocially, music therapy is known to facilitate expression, regulation, modulation, and alteration of emotions, alteration in mood, improved learning, increased motivation, increased self-

esteem, development of positive attitude towards life, and improved communication and social interactions.

**3. Cognitive adjustment, emotional regulation, and mood regulation during pregnancy:** Pregnancy is a major life event and pregnant women undergo significant changes in cognition as well as frequent emotional and mood changes. Several music therapy models or techniques are based on psychoanalytic, behavioural, or humanitarian models, which can facilitate life readjustment and mental self-organization, improved regulation of mood and emotions, resolution of conflicts, and promotion of overall wellbeing during pregnancy [8]. A study has shown that singing lullabies in pregnancy has soothing and calming effect, induces pleasure, facilitates expression of difficult emotions, and has significant effect on wellbeing [27].

**4. Pain reduction:** During pregnancy, women commonly experience lower back pain and muscle tensions, which are due to psychosomatic factors in addition to obvious physiological factors. Analgesic effects of music are known. Analgesic effects of music-based interventions can be explained by combination of multiple mechanisms such as central modulation of descending pain modulatory system, increased release of endorphins, distraction, induction of pleasure, improved sense of control, emotional alteration, muscular relaxation, and placebo effect [8, 28, 29]. A prospective randomized controlled trial has shown that progressive muscular relaxation accompanied by music caused significant improvement in pain and quality of life of pregnant women with low back pain as compared to control group [30].

**5. Reduced labour pain and other effects on delivery:** Different studies have shown that music therapy sessions during pregnancy, especially during the last trimester, reduce labor pain, reduce anxiety, facilitate delivery process, and may reduce incidence of Cesarean sections and length of first stage of labour in nulliparous women [6, 7, 31]. A recent study has shown that listening to classical music during third trimester of pregnancy can lower uterine contractions and therefore may prevent premature delivery [32]. The effects of antenatal music-based interventions on labor and delivery are believed to be due to stress reduction, relaxation, reduction in state-trait anxiety, and other physiologic changes. It should be noted that effects of music-based interventions during labor are not considered here, which have been addressed in many studies.

**6. Enhanced maternal-fetal relationship:** There are several studies showing improved maternal-fetal bonding through use of different music therapy techniques during labor and post-partum period. However, a few studies [6, 8, 33] have also shown enhanced maternal-fetal relationship when music-based interventions have been applied during pregnancy.

**7. Beneficial effects in pregnancy-induced hypertension (PIH):** PIH is a multifactorial condition seen in ~2% of pregnant women. A few studies have explored role of music therapy in PIH as an add-on treatment to conventional medicines and have shown better blood pressure lowering effect of medicines, decreased serum level of angiotensin II, decreased anxiety and depression, and improved quality of life [34].

**8. Encouragement for physical activity:** Positive effects of antenatal exercises and physical activity during pregnancy are known. Use of self-selected and stimulating music during physical exercise has shown to provide motivation for optimal exercise, to enhance effect, and to improve exercise performance through effects of music on central nervous system, especially on dopaminergic pathways [8, 35]. A study evaluating effects of exercise during pregnancy concluded that pregnant women would strive to exercise if exercise facilitators practice/remove outweighed psychological/physical barriers to exercise [36]; intervention in the study included music in group setting. Use of music for motivation towards desirable behaviors could help achieve clinical goals in an easier way and such approaches require further exploration.

**9. Decreased pre-procedural/pre-operative anxiety:** In general, reduction of pre-procedural and pre-surgical anxiety is a known application of music therapy. A randomized controlled trial has shown significant reduction in state-trait anxiety score in pregnant women undergoing non-stress test with use of music intervention [7]. In women who are planned for Cesarean section delivery, music therapy can be started during antenatal period for reduction of anxiety and to facilitate psychological preparation for the surgery. Anxiolytic effects of music during Cesarean section are already known [37, 38].

### **Mechanisms to show Effects of Music-based Interventions on Developing Fetus**

**1. Prevention of premature birth and low-birth weight and enhanced maternal-fetal relationship:** These effects

are already explained above. Premature birth and low-birth weight are associated with increased neonatal complications and music-based interventions during pregnancy can help to reduce risk of pre-term labor and pre-term delivery by reducing stress, anxiety and depression in pregnant women.

#### **2. Effects of music on fetal cardiac and motor activity:**

A recent study has shown that listening to classical music can stimulate fetal movements in pregnant women with non-reactive non-stress test [32]. Other studies have also shown that fetuses response to music by heart rate acceleration and motor responses [39, 40]. Fetal heart rate response to music changes with increasing gestational age and suggests maturity of central and autonomic nervous systems. Some researchers have proposed that fetal cardiac deceleratory response can be considered as physiologic equivalent to orienting reflex in infants and amplitude of such response is decreased upon repeated exposure to same auditory stimuli, suggesting habituation [41]. However, clinical applications of these effects need further research.

#### **3. Fetal neurodevelopment, fetal learning, and fetal memory:**

These are perhaps most fascinating targets/subjects of antenatal music therapy and underlying mechanisms are even more interesting. Modern neuroscience sees development of the human brain as a process that begins in utero and continues throughout the life. Processing of music by human brain is a highly complex process that involves multiple cortical and subcortical areas bilaterally and integrates auditory, cognitive, emotional, linguistic and sensory motor functions. Activation of temporal lobe in response to exposure to sound in brain of fetus of gestational age of at least 33 weeks has been confirmed by functional magnetic resonance imaging (fMRI) studies, suggesting sound processing by auditory cortex [42, 43]. Frontal lobe activation has also been observed in some studies [43].

Mechanisms to show effects of antenatal exposure to music on developing fetal brain are mostly based on indirect evidence, due to obvious reasons. Several animal studies suggest that exposure to music during antenatal period is associated with increased neurogenesis in hippocampus, motor cortex, and somatosensory cortex, increased cell density in parietal cortex, and increased morphological complexity of brain cells in fetal brain as well as enhanced spatial learning ability in rat pups, while exposure to noise affects the developing brain adversely [44, 45, 46, 47]. Effects of post-natal exposure of music, to developing brains of premature infants and full-term

newborns are already known [42] and are explained by multiple mechanisms such as multisensory stimulation, activation of multiple areas of brain, involvement of limbic and paralimbic system, triggering of emotional and cognitive components with distinct neural substrates, impact on reward system, etc. Different attributes of music such as type or genre, complexity, rhythm, tone, and harmony appear to influence overall effects of music on fetal neurophysiology, but evaluation of such effects require further investigation. In general, most studies have used classical music, but studies investigating effects of other types of music have also found positive results [44]. Overall, effects of antenatal music-based interventions on developing fetal brain form basis of fetal learning, fetal memory, and improved behavioral, cognitive, emotional, and social outcomes during infancy and early childhood.

**4. Effects of internal sounds on fetus:** Acoustic environment of a developing fetus includes both sounds in external environment of the mother and “internal” sounds such as sound of rhythmic maternal heart beats, bowel sounds, sounds generated by movement of amniotic fluid, other intra-abdominal sounds, breathing sounds, and mother’s voice (internally transmitted through tissues, with resonance provided by intra-abdominal spaces) [16, 48, 49].

Effects of maternal heart beats on neonates have been explored in some studies with mixed results. Facilitation of sucking, less crying, and modulation of arousal and sleep patterns have been observed in some studies [49]. Exposure of premature infants to womb-like sounds or to biological maternal sounds may improve cardio-respiratory stability and may reduce hypoxemic and bradycardic events [50, 51]. It is already known that mother’s voice is unique and special for every infant since birth and one of the reasons could be fetal memory due to antenatal exposure to mother’s voice to the fetus. Different studies have shown that exposure to mother’s voice could increase attention span, increase alertness, improve neonatal behavior (including nutritional behavior and sucking), improve sleep quality, decrease heart rate, and help/benefit neurobehavioral development of pre-term infants [52]. However, considering vast expanse of concept of “effects of internal sounds on fetus”, what we know till date is much less than what we need to know further.

## CONCLUSION

Music-based interventions are increasingly becoming popular because of their multidimensional beneficial effects to the mother and the fetus, relative safety, and

cost-effectiveness. Recent developments in stress physiology and psychoneuroendocrinology as well as better neuroimaging facilities have contributed much to understand effects of music medicine and music therapy on human psychophysiology. However, there are many unanswered questions, which require further research. In countries where music therapy is not established as an allied health science, it is important to sensitize health care professionals and medical researchers about music medicine, music therapy and other music-based interventions to improve quality of research. Also, in countries such as India, where music is a part of culture and traditions and where sounds and music have been used for healing since years, exploration of traditional music-based healing practices (for example, use of music and sound in Garbha Sanskara, Raga Cikitsa, Mantra chanting) with scientific approach is another necessity, because music therapy itself is highly influenced by socio-cultural background of patients.

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