


The Effect of Music on Human Physiology and Pathophysiology

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Abstract

The article reviews the effects of music on humans in human physiology and pathophysiology. There are reports on the role of music during pregnancy on mother and child (unborn and born). It has been reported that classic music (Bach, Mozart, Italian composers) have beneficial effects on cardiovascular parameters, whereas heavy metal or techno are without healthy effects. In other studies, the role of music has been evaluated in patients undergoing cardiac catheterization or open heart surgery. Music therapy is helpful in geriatric patients, those with depressive syndrome, terminal ill patients, and patients while on intensive care medicine. Vocal music and orchestral music produce significantly better correlations between cardiovascular or respiratory signals in contrast to uniform emphasis ($P < .05$). Music is effective under different conditions of the human life.

Keywords

music medicine, music therapy, procedural music therapy, clinical improvisation, palliative care, rhythmicity

The effects of music on humans have been well documented for thousands of years. There are several individual reactions to music that are dependent on individual preferences, mood, or emotions.^{1,2} It has been reported that music showed consistent cardiovascular and respiratory responses with different styles in most participants, in whom responses were related to tempo and were associated with faster breathing.^{3,4} The responses were qualitatively similar in musicians and nonmusicians and apparently not influenced by musical preferences, although musicians did respond more.

Music expresses what cannot be spoken and what is impossible to remain silent about.

Victor Hugo (1802-1885)⁵

In recent years, music has been increasingly used as a therapeutic tool in the treatment of different diseases.⁶⁻⁹ However, the physiological basis of music therapy is not well understood even in normal participants. The purpose of the present article is to summarize the different effects of music on health and to describe what kind of music is helpful for whom and what kind of music is probably “dangerous.”

Effects of Music on the Pregnant Woman

It is well known that music, as a stimulus, can be recognized as early as the 20th week of fetal development. The unborn baby will recognize all sounds and will “learn” music in this way.^{10,11} This is the first sensory impression for the child. There is general agreement that soft sounds with regular and low rhythms (lullabies) are ideal for the unborn baby or even

in children born before the regular date of birth. This is a well-known interaction between the baby and the mother and will help to avoid colic in newborns. In addition, music is also helpful for the mother prior to delivery. Yang et al¹² studied the effect of music on anxiety alleviation in 120 antepartal women on bed rest. These women received music therapy for 30 minutes on 3 consecutive days. Music was selected according to the women’s preferences. Usual care participants had a 30-minute rest on 3 consecutive days. Variables included anxiety (State-Trait Anxiety Inventory), and physiological responses like vital signs and fetal heart rate. Anxiety levels decreased and physiological responses improved significantly in the women with music therapy while on bed rest. In another study by Kim et al,¹³ it was suggested to play music for women during pregnancy, birth, and nursing. Increased sympathetic activity during pregnancy has been proposed as a mechanism for increased incidence of arrhythmias and, therefore, music may help to avoid them.^{14,15} Occurrence of cardiac tachyarrhythmias may also be related to physiologic changes occurring during pregnancy, such as increased heart rate, decreased peripheral resistance, and increased stroke volume. Arrhythmias during pregnancy are a very real cause of maternal and neonatal morbidity and mortality. Music with slow rhythms, soft sounds,

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and particularly music from Mozart is beneficial in these circumstances and opens new possibilities for the unborn (and born) babies as well as for the mother. It seems possible to prevent cardiac arrhythmias for both mother and unborn child as well as to prevent sudden infant death. In addition to these cardiovascular effects, there is a significant improvement in cognitive function (Binet intelligence scale) when listening to Mozart's music (score 57.56) compared to relaxation (score 54.61) or silence (score 54.00) ($P < .002$). In relation to each other, the relaxation and silence conditions did not differ ($P = .43$).¹⁶ Music may also be helpful in instances of depression and more specifically postpartum depression.¹⁷ It seems that Mozart has beneficial effects on energy expenditure in growing preterm infants.¹⁸

Effects of Music on the Cardiovascular System

Bernardi et al¹⁹ studied 24 young healthy participants (12 chorists and 12 nonmusician control participants) who listened in random order to music with vocal (Puccini's *Turandot*) or orchestral (Beethoven's Ninth Symphony adagio) progressive crescendos, more uniform emphasis (Bach's Cantata BWV 169 "Gott soll allein mein Herz haben"), 10-second rhythmic phrases (Verdi's arias "Va pensiero" and "Libiam nei lieti calici") or silence while heart rate, respiration, blood pressure, middle cerebral artery flow velocity, and skin vasomotion were recorded. Vocal and orchestral crescendos produced significant correlations between cardiovascular or respiratory signals and musical profile, particularly skin vasoconstriction and blood pressures, proportional to crescendo, in contrast to uniform emphasis, which induced skin vasodilation and reduction in blood pressure ($P < .05$). Ten-second phrases from Verdi arias entrained the cardiovascular autonomic variables. It is important to note that no qualitative differences were observed in recorded measurements between musicians and nonmusicians. In this study, cerebral flow was significantly lower when listening to "Va pensiero" (70.4 ± 3.3 cm/s) compared to "Libiam nei lieti calici" (70.2 ± 3.1 cm/s; $P < .02$) or Bach (70.9 ± 2.9 cm/s; $P < .02$). There was no significant influence on cerebral flow in Beethoven's Ninth Symphony during rest (67.6 ± 3.3 cm/s) or listening (69.4 ± 3.1 cm/s). The results by Bernardi et al¹⁹ also demonstrate that in addition to conscious chills, which typically are experienced by a minority of participants, a common pattern of unconscious response is visible when different participants listen to the same music. These autonomic responses were more apparent with lyrical responses from an operatic aria or a typical exciting orchestral phrase than with more "intellectual" solo singing from a Bach cantata. The extent of the responses appeared to be dependent on the specific pattern of the musical profile. When a sudden crescendo was paced adequately, or the musical profile exhibited a constant or a slow change, then the cardiovascular system tracked the musical profile, and skin vasomotion was evident. When the musical profile changed very rapidly, the effect was opposite. Skin vasomotion and a reduction in blood pressure by

general relaxation were observed.¹⁹ Bernardi worked with Peter Sleight from the department of cardiovascular medicine, John Radcliffe Hospital Oxford, United Kingdom, and they showed that one factor mediated the physiological effect of listening to music: tempo. Fast music caused increases in blood pressure, heart rate, and breathing rate and reduced baroreflex sensitivity. Slow music caused a significant fall in heart rate and breathing frequency compared with the baseline. They also observed another effect: slow-tempo music seemed to lower heart rate more when it followed a faster piece of music than when it came first. Quicker music has an arousing effect on the system which concentrates on attention. Another important observation made by Bernardi and Sleight had to do with the effect of the 2-minute silence in the middle of the music sequence.¹⁹ It had a greater impact in reducing heart rate and blood pressure than did the slowest tempo music. Silence between music had the most profound relaxing effect.

It has been shown by Yoshie et al²⁰ and Nakahara et al²¹ that music will have beneficial effects on heart rate, heart rate variability, and anxiety levels in not only skilled pianists but also nonmusicians during both performance and listening to music. The findings of these studies suggest that musical performance has a greater effect on emotion-related modulation in cardiac autonomic nerve activity than musical perception.^{22,23}

It has been shown that the structure of a piece of music has a constant dynamic influence on cardiovascular and respiratory responses, which correlates with musical profiles.^{24,25} Specific musical phrases (frequently at a rhythm of 6 cycles/min in famous arias by Verdi) can synchronize inherent cardiovascular rhythms, thus modulating cardiovascular control. This occurred regardless of respiratory modulation, which suggests the possibility of direct entrainment of such rhythms and led to the speculation that some of the psychological and somatic effects of music could be mediated by modulation or entrainment of these rhythms.²⁶ Music as therapy is an option for all since it has been reported that musicians and nonmusicians alike showed similar qualitative responses (cardiovascular and respiratory system). This suggests that "active" playing of music is not essential to induce synchronization with music. However, it was pointed out that musicians appeared to show higher cardiovascular and respiratory modulations induced by music, particularly when music by Bach or Mozart was played.²⁷⁻²⁹

Effect of Music During Cardiac Catheterization

Argstatter et al³⁰ analyzed the role of music in 90 patients who underwent cardiac catheterization. There were 3 randomized groups: group I represented patients with "music only" during catheterization procedures, group II patients had both music during catheterization and extended information prior to the procedure, and group III patients served as controls. In all groups the anxiety score was evaluated with the categories "minimal anxiety—minimal stress" or "severe

Table 1. Cortisol Levels in Volunteers Undergoing Music With Bach, Heavy Metal, or Noise

	Control	Bach	Heavy Metal	Noise
M < 50 yrs	12.4 ± 5.0 µg/dL	8.9 ± 3.1 µg/dL P = .031	10.9 ± 3.2 µg/dL P = .120	10.0 ± 4.6 µg/dL P = .110
F < 50 yrs	11.1 ± 4.7 µg/dL	9.9 ± 4.6 µg/dL P = .050	11.1 ± 5.7 µg/dL P = .378	10. ± 4.2 µg/dL P = .604
M ≥ 50 yrs	13.3 ± 4.9 µg/dL	9.9 ± 4.3 µg/dL P = .001	8.9 ± 2.9 µg/dL P = .001	9.9 ± 3.6 µg/dL P = .002
F ≥ 50 yrs	12.1 ± 6.3 µg/dL	10.0 ± 6.0 µg/dL P = .005	11.1 ± 4.4 µg/dL P = .254	10.6 ± 4.9 µg/dL P = .520

Abbreviations: F, females; M, males; yrs, years.

anxiety—severe stress.” It was becoming clear that the behavior during the procedure was significantly better in groups I and II patients in contrast to controls ($P < .05$). However, there were no significant differences in heart rate and blood pressure among the 3 groups. In addition, similar drug regimens were used prior to and after the procedure. Recently, in a study by Goertz, the effect of different types of music during cardiac catheterization procedures was analyzed by an anxiety score system among patients who had music during the procedure compared to those who did not.³¹ In addition to the anxiety score, heart rate and blood pressure were recorded. There were patients who listened to classical music, meditation music, jazz, or silence. In patients who were not able to select their own music, the most beneficial effect was seen in those who had classical music. Although there were significant differences in the anxiety index between patients with or without music ($P < .05$), no significant differences among the 2 groups were observed in heart rate or blood pressure.

Effect of Music Prior to and After Cardiac Surgery

The influence of music was studied prior to bypass grafting or valve replacement in 372 patients wherein a portion of the group received midazolam (0.05-0.1 mg/kg) according to the State-Trait Anxiety Inventory (STAI)-X-1 anxiety score.³² Of the 372 total patients, there were 177 patients who had music prior to surgery and 195 patients who received midazolam. There were significant differences in the anxiety scores prior to and after surgery between both groups: in the “music group” prior to and after surgery the score was 34 and 36, respectively, whereas the score was 30 and 34 in the midazolam group ($P < .001$). Nilsson³³ analyzed 40 patients who underwent bypass grafting or aortic valve replacement, and in these patients oxytocin, heart rate, blood pressure, partial pressure of O₂ in arterial blood (measured in mmHg; PaO₂), and oxygen saturation arterial O₂ saturation (measured in %; SaO₂) were studied in 2 groups: one group had music and the other group served as controls. As pointed out by the authors, there were significantly better values of oxytocin (increased) and PaO₂ (increased) in the music group compared to controls ($P < .05$). No significant differences were observed regarding heart rate, blood pressure, and SaO₂. In another study, Nilsson³⁴ analyzed the follow-up

of 58 patients after cardiac surgery. These patients underwent musical therapy (30-minute music exposure 1 day after surgery) compared to controls. Cortisol level, heart rate, ventilation, blood pressure, SaO₂, pain, and anxiety indices were evaluated. Significantly lower cortisol levels were found in the music group (484.4 mmol/L) than in the group of patients without music (618.8 mmol/L; $P < .02$).³² There were no significant differences in heart rate, blood pressure, respiration, and oxygen saturation between both the groups. Similar effects have been reported by Antonietti in patients who underwent rehabilitation after surgery.³⁵

Effects of Music on Intensive Care Patients, Geriatric, and Terminally Ill Patients

It is well known that soft and not loud sounds have beneficial effects on patients while treated in intensive care medicine and will reduce pain and stress significantly.³⁶ Soft classical or meditation music is associated with the reduced need for sedative drugs and reduced perception of pain. Despite well-known effects of music in intensive care medicine, this kind of “therapy” is observed rarely in daily practice. In addition to this, there are many psychological effects: music from the youth of the patient and music with slow tempi are essential for the intensive care patient. There are spectacular effects of music in geriatric patients: music from the youth and music from “better days” will lead to improved mood, motivation, and increased vitality and will also encourage social contacts.³⁶ This is important both in geriatrics and in patients with depressive syndromes. Chan et al³⁷ performed a randomized study in 47 patients <65 years who underwent music therapy compared to 24 controls. In the music group, there were statistically significant decreases in depression scores ($P < .001$), blood pressure ($P < .001$), and heart rate ($P < .001$) after 1 month ($P < .001$). Therefore, music can be an effective intervention for older and/or patients with depressive syndromes. Patients with Alzheimer diseases will also profit from music therapy. We all know that the terminal patient presents a unique situation. It has been reported that these patients will continue hearing although some other organ functions have been lost. Music plays an important role in this situation and music from the patient’s youth has the most impact. This music might prove to be the

last source of aesthetic enjoyment and simple happiness for the dying patient.^{38,39}

Effects of Bach or Heavy Metal in Humans

The most beneficial music for patient's health is classical music.⁴⁰ It has been shown that music by Bach, Mozart, or Italian composers are most powerful in "treating" patients. It seems possible to select "ideal" therapy for cardiovascular disturbances, recreation, and refreshment of the immune system, improvement of concentration, and in patients with depressive syndromes. The beneficial effects of Bach's music are possibly caused by his typical composition style, avoiding sudden changes. Heavy metal and techno are ineffective on human health. This music encourages rage, disappointment, and aggressive behavior while causing both heart rate and blood pressure to increase. We studied recently the cortisol levels in 60 healthy volunteers (30 males and 30 females). There were 30 volunteers <50 years old (mean age females 34 ± 8 [range 25-49] years; mean age males 37 ± 8 [range 25-47] years) and 30 volunteers ≥ 50 years old (mean age females 56 ± 5 [range 50-71] years; mean age males 57 ± 7 [range 50-74] years) in a prospective randomized trial. All volunteers underwent music application with Bach (Orchestral Suite No. 3 in D major), heavy metal (Disturbed), or noise (drilling machine, air hammer, blow dryer, crying children). Significantly lower cortisol levels were observed in the Bach group compared to heavy metal or noise (Table 1). Study results will be written in detail when all results are present and submitted separately.

When is Music Not Useful?

More recently, several reports have indicated the usefulness of music therapy in managing psychiatric disorders.^{41,42} Music has been used in the treatment of psychosis and neurosis and now is being used in addressing organic disorders such as dementia. It plays a useful role in allaying anxiety and relaxing patients in critical care. Music therapy has been used effectively in both adults and children with psychiatric disorders. It has been used to modify the behavior of children with autism and pervasive developmental disorders with moderate success. It has been used to reduce agitation in patients with dementia by soothing them and eliminating the social isolation of these patients.^{43,44} Music therapy has been used in patients with Parkinson disease to improve motor skills and to deal with emotional problems.⁴⁵ Music no doubt plays a pivotal role in the lives of human beings. Incorporating music therapy into regular therapy programs for psychiatric disorders can help speedy recovery and also help make therapy a more positive experience. Music therapy is a valuable but relatively unexplored asset in the field of psychiatry and psychotherapy. However, the patient may or may not like the music chosen by the physician and thus is given a choice to include music or not. Careful selection of music that incorporates patient's own preferences may yield positive results, whereas contrary effects may result from the use of the wrong type of music. Selection of "wrong"

music can intensify depressive syndromes, aggressiveness, and anxiety. In addition, feelings toward music may change during different phases of life and may lead to different effects. Excellent articles analyzing individual music therapy for depression or pain management have been published recently by Bernatzky et al.⁴⁶ and Erkkilä et al.⁴⁷

Conclusion

Music is used more and more as a therapeutic tool, because all participants, whether musically trained or not, respond in a similar manner. Music is a combination of frequency, beat, density, tone, rhythm, repetition, loudness, and lyrics. Different basic personalities tend to be attracted to certain styles of music. Energy block patterns can intensify, reduce, or change the natural inclinations of a person's identity. Music influences our emotions because it takes the place of and extends our languages. Research studies conducted over the past 10 years has demonstrated that persistent negative emotional experiences or an obsession and preoccupation with negative emotional states can increase one's likelihood of acquiring common cold, other viral infections, yeast infestations, hypersensitivities, heart attacks, high blood pressure, and other diseases. For better personal health, we can then choose "healthful" music and learn to let ourselves benefit from it. The most benefit from music on health is seen in classical music, whereas heavy metal or techno are ineffective or even dangerous. There are many composers that effectively improve quality of life and health, particularly Bach, Mozart, or Italian composers. Music is effective under different conditions and can be utilized as an effective intervention in patients with cardiovascular disturbances, pain, depressive syndromes, psychiatric diseases, and in intensive care medicine. The hypothesis that Bach's or Mozart's music is helpful on health has to be proved by prospective, randomized studies on animals and humans.

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