

The effects of music on the cardiovascular system and cardiovascular health

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ABSTRACT

Music may not only improve quality of life but may also effect changes in heart rate and heart rate variability. It has been shown that cerebral flow was significantly lower when listening to 'Va pensiero' from Verdi's 'Nabucco' (70.4 ± 3.3 cm/s) compared with 'Libiam nei lieti calici' from Verdi's 'La Traviata' (70.2 ± 3.1 cm/s) ($p < 0.02$) or Bach's Cantata No. 169 'Gott soll allein mein Herze haben' (70.9 ± 2.9 cm/s) ($p < 0.02$). There was no significant difference in cerebral flow during rest (67.6 ± 3.3 cm/s) or when listening to Beethoven's Ninth Symphony (69.4 ± 3.1 cm/s). It was reported that relaxing music significantly decreases the level of anxiety of patients in a preoperative setting (State-Trait Anxiety Inventory (STAI)-X-1 score 34)—to a greater extent even than orally administered midazolam (STAI-X-1 score 36) ($p < 0.001$). In addition the score was better after surgery in the music group (STAI-X-1 score 30) compared with the midazolam group (STAI-X-1 score 34) ($p < 0.001$). Higher effectiveness and absence of apparent adverse effects make relaxing, preoperative music a useful alternative to midazolam for premedication. In addition, there is sufficient practical evidence of stress reduction suggesting that a proposed regimen of listening to music while resting in bed after open-heart surgery is important in clinical use. After 30 min of bed rest, there was a significant difference in cortisol levels between the music (484.4 mmol/l) and the non-music group (618.8 mmol/l) ($p < 0.02$). Vocal and orchestral music produce significantly better correlations between cardiovascular or respiratory signals compared with music with a more uniform emphasis ($p < 0.05$). The greatest benefit on health is visible with classical music and meditation music, whereas heavy metal music or techno are not only ineffective but possibly dangerous and can lead to stress and/or life-threatening arrhythmias. The music of many composers most effectively improves quality of life, will increase health and probably prolong life, particularly music by Bach, Mozart or Italian composers.

INTRODUCTION

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 of different styles showed consistent cardiovascular and respiratory responses in most subjects, in whom responses were related to tempo and were associated with faster breathing.^{3 4} The responses were qualitatively similar in musicians and non-musicians, and apparently were 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.^{6–8} However, the physiological basis of music therapy is not well understood even in normal subjects.⁹ The purpose of the present review is to summarise the different effects of music on health and the cardiovascular system.

MUSIC, HEALTH AND MEDICINE: A TOPIC FOR EVERYBODY?

It is well known that music can evoke emotional responses that improve quality of life but, by the same token, they can also induce stress and aggressiveness.¹⁰ Music may enhance positive or calming emotions and has played an important role in the 'making of health' throughout human history through its use in rituals and religious services. Music improves concentration but has different neurophysiological aspects, the effectiveness of which is governed by individual preferences. The role of music correlates with music profiles, and continuous 'mirroring' of music profiles appears to be present in all subjects, regardless of musical training, practice or personal taste, even in the absence of accompanying emotions.¹¹ The ability of music to increase physical work activity has been documented for 2800 years. In Ancient Greece, the kithara (κίθαρα—a harp-like instrument held on the lap) and flute music was played during the Olympic Games with the goal of improving sporting activities. It has been shown that this led to better athletic performances (improvement ~15%) (figure 1). In addition, not only is the effect of music on exercise training well known, but music therapy is also increasingly used in different disciplines, from patients with neurological disease to intensive care and palliative medicine.^{12–14}

Brain and heart: the power of music to enhance memory and learning

The human brain is divided into two hemispheres, and the right hemisphere has been traditionally identified as the seat of musical appreciation (figure 2). However, no one has found a 'musical centre' there, or anywhere else. Studies of musical understanding in people who have damage to either hemisphere, as well as brain scans of people taken while listening to music, reveal that music perception emerges from the interplay of activity in both sides of the brain. Some brain circuits respond specifically to music; but, as you would expect, parts of these circuits participate in other forms of



Figure 1 Influence of music (lyra and tibia players) on effectiveness in Olympic athletes. Painting from Tarquinia, Etrusien (reproduction).

sound processing. For example, the region of the brain dedicated to perfect pitch is also involved in speech perception. Music and other sounds entering the ears travel to the auditory cortex, assemblages of cells just above both ears. The right side of the cortex is crucial for perceiving pitch as well as certain aspects of melody, harmony, timbre and rhythm. The left side of the brain in most people excels at processing rapid changes in frequency and intensity, in both music and words. Both the left and right sides are necessary for complete perception of rhythm. The frontal cortex of the brain, where working memories are stored, also plays a role in rhythm and melody perception. Other areas of the brain deal with emotion and pleasure. The power of music to affect memory is quite intriguing. Mozart's music and baroque music, with a pattern of 60 beats per min, activate both the left and right brain. The simultaneous left and right brain action maximises learning and retention of information. The information being studied activates the left brain while the music activates the right brain. Also, activities which engage both sides of the brain at the same time, such as playing an instrument or singing, cause the brain to become more capable of processing information (figure 3).

Physiological effects of music on the cardiovascular system

Recently, interest has begun to be taken in the cardiovascular, respiratory and neurophysiological effects of listening to music, including the brain areas involved, which appear to be similar to those involved in arousal. Bernardi *et al*¹⁵ recently studied 24 young, healthy subjects (12 choristers and 12 non-musician control subjects) who listened in random order to music with

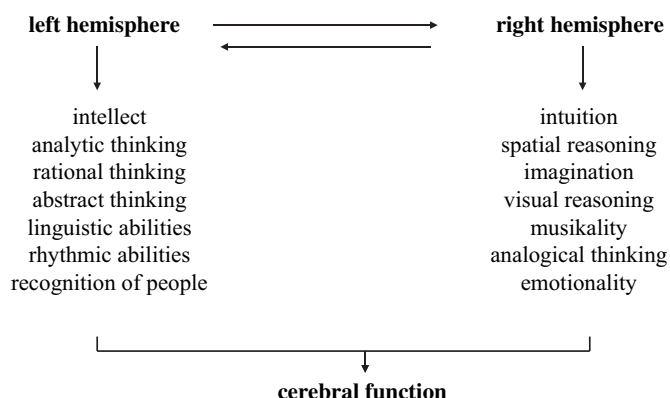


Figure 2 Brain association areas. Localisation of different functional areas in the left or right brain hemisphere.

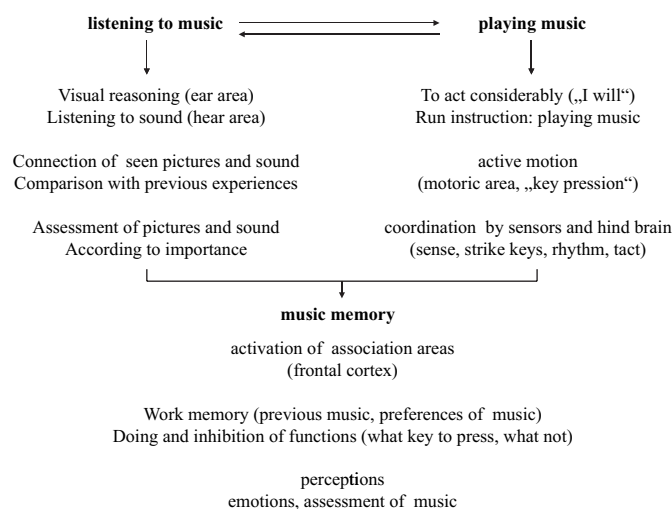


Figure 3 Processes and responses associated with listening to music, playing music and musical memory.

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 s period rhythmic phrases (Verdi's arias 'Va pensiero' and 'Libiam nei lieti calci') or silence while heart rate, respiration, blood pressure, middle cerebral artery flow velocity and skin vasomotion were recorded. Common responses were recognised by averaging instantaneous cardiorespiratory responses regressed against changes in musical profiles and by coherence analysis during rhythmic phrases. 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 a reduction in blood pressure ($p < 0.05$). Correlations were significant in both individual and group-averaged signals ($p < 0.05$). Phrases at 10 s intervals by Verdi entrained the cardiovascular autonomic variables. It is important to note that no qualitative differences were observed in recorded measurements between musicians and non-musicians. In this study cerebral flow was significantly lower when listening to 'Va pensiero' (70.4 ± 3.3 cm/s) compared with 'Libiam nei lieti calci' (70.2 ± 3.1 cm/s) ($p < 0.02$) or Bach (70.9 ± 2.9 cm/s) ($p < 0.02$). There was no significant influence on cerebral flow of Beethoven's Ninth Symphony (rest 67.6 ± 3.3 cm/s, music 69.4 ± 3.1 cm/s). Grewe *et al*¹⁶ observed that some subjects occasionally experienced the sensation of chills during sudden crescendi, together with cardiovascular changes. The data of Bernardi *et al*¹⁵ also demonstrate that in addition to conscious chills, which typically are experienced by a minority of subjects, there is a common pattern of unconscious response when different subjects 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 spaced adequately, or the musical profile exhibited a regular or slow change, then the cardiovascular system tracked the musical profile, and skin vasomotion was evident. When the musical profile changed very rapidly, the overall effect was the opposite. Skin vasomotion and a reduction in blood pressure by general relaxation were observed. It has

been shown in other studies by Yoshie *et al*¹⁷ and Nakahara *et al*¹⁸ that music will have beneficial effects on heart rate, heart rate variability and anxiety levels not only in skilled pianists but also in non-musicians during both performance of and listening to music. The findings of these studies suggest, though, that musical performance has a greater effect on emotion-related modulation in cardiac autonomic nerve activity than musical perception.^{19 20} In contrast, heavy metal or techno music can lead to stress and restlessness, sleep disturbances, fatigue, exhaustion, impairment of the immune system, hardness of hearing and/or loss of hearing.²¹

Music and cardiovascular diseases

Recently, several studies have analysed the effect of music during cardiac catheterisation, prior to and after cardiac surgery and during rehabilitation. In addition, there are some reports that studied the effect of music in intensive care medicine, in geriatrics and in patients with neurological diseases or depressive syndromes. It is essential to note that studies have shown that music has beneficial effects on different physiological parameters and will become an important option when treating these patients.

Effect of music on the cardiovascular system

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. It was pointed out that the cardiovascular (particularly skin vasomotion) and respiratory fluctuations mirrored the musical profile, thus highlighting its importance in relation to the therapeutic use of music. Specific musical phrases (frequently at a rhythm of 6 cycles/min in famous arias by Verdi) can synchronise 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.¹⁶ Music as therapy is an option for all since it has been reported that musicians and non-musicians alike showed similar qualitative responses (cardiovascular and respiratory system). This suggests that 'active' playing of music is not essential to induce synchronisation with music.¹ However, it was pointed out that musicians appeared to show higher cardiovascular and respiratory modulation induced by music. They also tended to respond more than non-musicians to more 'intellectual' music such as that of Bach or Mozart.^{1 15} If music induces similar physiological effects in musicians and non-musicians, standard 'music therapeutic' interventions would be possible. Therefore, it seems necessary to identify different effects of music under different conditions.^{5 6} Is the music written by Bach or Mozart helpful for everybody? Is classical music better than heavy metal or techno? What music has beneficial effects in intensive care medicine and in patients with cardiovascular diseases? Are responses to rhythmic phrases different from the effect of silence?

Effect of music during cardiac catheterisation

Argstatter *et al*²² analysed the role of music in 90 patients who underwent cardiac catheterisation. There were three randomised groups: group I represented patients with 'music only' during catheterisation procedures; group II patients had both music during catheterisation 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 anxiety—severe stress'. It

became clear that the behaviour during the procedures was significantly better in group I and group II patients compared with controls ($p < 0.05$). However, there were no significant differences in heart rate and blood pressure between the three groups. In addition, similar drug regimens were used prior to and after the procedure. Recently, in the Almut study the effect of different types of music during cardiac catheterisation procedures was analysed by an anxiety score system in patients who listened to music during the procedure compared with those who did not.²³ 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 listened to classical music. In patients who selected their own music, meditation music was most powerful. Although there were significant differences in the anxiety index between patients with or without music ($p < 0.05$), no significant differences among the two 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.²⁴ Of the 372 total patients, there were 177 patients who listened to 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 ($p < 0.001$). Nilsson *et al*²⁵ analysed 40 patients who underwent bypass grafting or aortic valve replacement and in these patients oxytocin, heart rate, blood pressure, PaO₂ and oxygen saturation SaO₂ were studied in two groups: one group listened to music, 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 with the controls ($p < 0.05$). No significant differences were observed regarding heart rate, blood pressure and SaO₂. In another study, Nielsson *et al*²⁶ analysed the follow-up of 58 patients after cardiac surgery. These patients underwent musical therapy (30 min music exposure 1 day after surgery) and were compared with controls. Evaluation of cortisol, heart rate, ventilation, blood pressure, SaO₂, pain and anxiety indices was performed. There were significantly lower cortisol levels in the music group (484.4 mmol/l) compared with patients without music (618.8 mmol/l) ($p < 0.02$). There were no significant

Table 1 Recommended classical music in cardiovascular disturbances

Composer	Music
Tomaso Albinoni	Adagio G-minor for organ and strings
Johann Sebastian Bach	Brandenburg concertos (BWV 1046–1051) Cantata No. 147 'Herz und Mund und Tat und Leben' (BWV 147) Air from the Orchestral Suite No. 3 (BWV 1068) The Well-Tempered Clavier (BWV 846-869)
Arcangelo Corelli	Adagio
Georg Friedrich Händel	Water music 'Arrival of the Queen of Sheba' (from 'Solomon')
Wolfgang Amadeus Mozart	Andante and variations G-major for organ with four hands (KV 501)
Giuseppe Tartini	Adagio cantabile

BWV, Bach works catalogue; KV, Köchel-Verzeichnis; Mozart works catalogue.

differences in heart rate, blood pressure, respiration and oxygen saturation between both groups. Similar effects have been reported by Antonietti in patients who underwent rehabilitation after surgery.²⁷

CHOOSING APPROPRIATE MUSIC: WHAT TYPES OF MUSIC ARE GOOD FOR HEALTH AND WHICH ARE NOT?

The most beneficial music for the health of a patient is classical music, which plays an important role in music therapy. It has been shown that music composed by Bach, Mozart and Italian composers is the most powerful in 'treating' patients. It is possible to select the 'ideal' therapy for cardiovascular disturbances, recreation and refreshment of the immune system, improvement of concentration and help with depression (table 1). Patients who would derive the most benefit from classical music include those with anxiety, depressive syndromes, cardiovascular disturbances and those suffering from pain, stress or sleep disturbances. Popular music is an 'eye-opener'. This music incorporates harmonic melodies that will lead to a buoyant spirit, a lift in mood, increased motivation and general stimulation. Meditation music has sedative effects. Sounds are slow and rhythms few. This kind of music generates spiritual reflection and, as such, is utilised in Yoga and Tai Chi. Heavy metal and techno are ineffective or even dangerous. This music encourages rage, disappointment and aggressive behaviour while causing both heart rate and blood pressure to increase. Breastfeeding mothers should avoid this music because there is a negative influence on milk flow.²¹ In addition, plants have been shown to slow their growth or even die when exposed to this kind of music on a permanent basis. Hip hop and Rap are less frequently effective due to the sounds, but can often have an effect due to their words—the important element of which is the rhyme structure. Jazz appeals to all the senses, but a high degree of concentration is necessary when listening to jazz. There are few studies of the effect of jazz on health. Latin-American music such as the samba, tango, cha-cha-cha, rumba, reggae or mambo is very rhythmic. This music leads to a positive mood and buoyant spirit, and induces movement. It increases motivation and stimulates activity. Folk is music with a socio-cultural background. It is enriching for intellectual work, leads to confidence and emphasises protection. However, if folk music is 'unusual' in character it can have a negative effect. Schlager music are songs to sing alone with, have simple structures but frequently have an 'earworm character'. This kind of music is inappropriate for influencing health.^{6 21}

CONCLUSIONS

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. Music influences our emotions because it takes the place of and extends our languages. Research 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 the 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 in terms of health is seen for classical and meditation 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 and Italian composers. Various studies have suggested that this music not only makes one happy, but also has significant effects on the cardiovascular system and significantly influences heart rate, heart rate variability and blood pressure as well. Music is effective under different conditions and can be utilised as an effective intervention in patients with cardiovascular disturbances, pain, depressive syndromes, psychiatric diseases and in intensive care medicine. Therefore, music plays an important role in people's lives and, by extension, an important role in medicine.

Competing interests None.

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