INVITED PAPER:

Music and blood pressure - risk, therapeutic or simply pleasure?

Martin Paul
Chair, Clinical Pharmacology
Maastricht University, Maastricht, The Netherlands

DOI: 10.30824/2006-8

Is music a cardiovascular risk factor? Yes, if one believes the events unfolding in the second act of Jacques Offenbach's opera fantastique "The tales of Hoffmann" which is based on the short stories of E.T.A. Hoffmann, a German writer who lived at the turn of the 18th to the 19th century. In this opera Antonia, the young daughter of a respected city councilor in Munich, is suffering from a mysterious condition where she has to refrain from singing, which has had deleterious effects on her health. Unfortunately, after being tricked to break into song (after all it is an opera) by a malicious house guest she tragically dies from an apparent heart attack in front of the eyes of her father and her unfortunate lover, Hoffmann (Figure 1).

Of course, this fantastic story is pure fiction, but what do we know about the cardiovascular effects of music in the real world?

Music is not a one-dimensional entity. It is characterized by several elements that could have individual or combined effects: timbre (sound quality), pitch (frequency), tempo (fast or slow), duration and sound dynamics (loud or quiet), just to name a few. Studies investigating the effects of music on cardiovascular function mostly ignore the multifactorial impact of music on body and mind, making it difficult to pinpoint physiological and pathophysiological effects induced by single factors.

Independently thereof, it is generally accepted that music has effects on heart rate and blood pressure as has been shown in many studies that have been elegantly summarized by Koelsch and Jaehnke [6]. Emotional arousal by exciting music leads to (relatively mild) increases in heart rate and blood pressure through sympathetic pathways whereas calming music has the opposite effects by inducing parasympathetic mechanisms. In addition, heart rate variability is consistently lower by listening to exciting rather than calming music.

Figure 1: The death of Antonia. Photograph from the premiere performance of " The tales of Hoffmann", Opera Paris, 1881

These principles have also been the scientific basis to investigate "music therapy" as a means to lower blood pressure. In a study by Sutoo and Akiyama [10], spontaneously hypertensive rats were subjected to a soothing piece by Mozart (Adagio from Divertimento Nr. 7, KV 205) and systolic blood pressure was significantly and dramatically decreased by 13 to 24 mm Hg. By pharmacological characterization, the authors largely attributed the mechanism to the calcium-calmodulin induced brain synthesis of dopamine reducing blood pressure through the D2 receptor.

Similar effects have also been described in studies investigating the effects of music on blood pressure in humans. Chafin et al [2] assigned study participants to a challenging arithmetic test and then made them listen to different styles of music, demonstrating that classical music (as opposed to other musical styles) facilitated the blood pressure recovery from stress. A metanalysis by Kuehlmann and coworkers[7] showed blood pressure lowering trends of both, systolic (Figure 2) and diastolic blood pressure but could not confirm causality between musical intervention and blood pressure lowering effects. Nevertheless, the authors suggested that listening to music could be used as a complementary approach to pharmacological hypertension therapy.

But going back to the story of poor Antonia mentioned above, what about the potential negative effects of music on the cardiovascular system? It has been suggested that those exposed extensively to a musical environment, such as orchestra musicians, have significant health risks.

As discussed previously in a review published in German[9] several studies have shown that the level of psychosocial stressors among members of symphony orchestras is higher than in the average working population[5], although psychosocial stress patterns are variable and related to different musical styles. A number of external factors must be considered in this context that are independent of the exposure to music and due to stress triggers such as irregular working hours, lack of time and pressure to meet deadlines as well as nervousness before the start of a performance (stage fright). Mulcahy et al.[8] investigated the influence of rehearsals and performances of various concerts in an English Symphony Orchestra by ECG monitoring. The authors were able to show that the heart rate of musicians was significantly increased during rehearsals and performances, in conjunction with shifts in circadian rhythm. Interestingly, this effect was also dependent on the compositional style. For example, results showed that the heart rate was significantly higher in performances of pieces by Tchaikovsky and Rachmaninov than in performances of music by Mozart. Interestingly, the fluctuations in heart rate were also present and even more pronounced among the supporting staff.

Bernardi et al. [1] investigated the influence of different musical styles and movements on cardiovascular, cerebrovascular, and respiratory changes and examined both musicians and non-musicians. They were able to demonstrate that at fast tempos and rhythms, blood pressure, heart and respiratory rate were increased and cerebral flow velocity and baroreflex activity decreased. Interestingly, a habituation effect after repetition of the musical stimuli could not be measured. Musicians had a more pronounced respiratory response if they were compared to non- musicians. The authors concluded that music induces an "arousal effect" and that this effect is mainly associated with fast tempi. Slow tempi and pauses in contrast, tended to lead to a relaxation reaction.

Next to rhythm, sound levels and dynamics can also influence cardiovascular function and be related to blood pressure effects and hypertension. This has been studied in large human populations outside the musical arena. A case-control study by Zeeb et al.[12] conducted in the vicinity of an international airport in 137,577 cases and 355,591 controls, for example, has pointed to a clear association between (traffic) noise levels and clinical hypertension. Fogari et al.[4] had already reported earlier that chronic noise exposure above a threshold of 80 decibels was associated with an increased prevalence of hypertension in over 8000 workers in a metal processing factory. These exposures are comparable to noise levels in the orchestra pit and a study of orchestra musicians[11] showed that values of sometimes well over 90 db are also reached in this area, which could indicate an increased cardiovascular risk in this population similar to the populations mentioned above. However, there are no detailed studies yet that establish a causal connection between the cardiovascular risk, blood pressure effects and increased sound levels in the orchestra environment. For other areas exposed to chronically elevated sound volumes, such as traffic noise, the underlying mechanisms point

towards a pathophysiological role of oxidative stress and vascular inflammation, as recently has been summarized by Daiber et al[3], attributed to dysregulation of endothelial/neural nitric oxide synthase (NOS). It remains to be seen if similar effects are relevant in the orchestra pit. Interestingly, there have been some anecdotal reports of cardiovascular events of orchestra conductors occurring during the performance[9], but one cannot conclude from these singular cases that there are causal links between sound exposure and the disease event.

In summary, it must be noted that music can have a variety of effects on cardiovascular function. Factors such as sound dynamics, volume, tempo and rhythm lead to changes in parameters such as blood pressure and heart rate. However, the evidence is not sufficient at this stage to attribute an increased cardiovascular risk to the workplace in the orchestra pit and on the concert stage, as there are no large case-control studies in humans in this area. Concerning the possible beneficial effects of music therapy, at one can at best suggest that this approach could be used as a complementary measure to established therapies. In terms of risk management, hypertensive individuals should certainly continue to enjoy listening to music. As with everything (and I am thinking again about poor Antonia in Offenbach's opera) maybe one should not overdose, as is the advice attributed to the medieval physician Paracelsus who supposedly said that "the dosage makes it either a poison or remedy".

Martin Paul - m.paul@maastrichtuniversity.nl

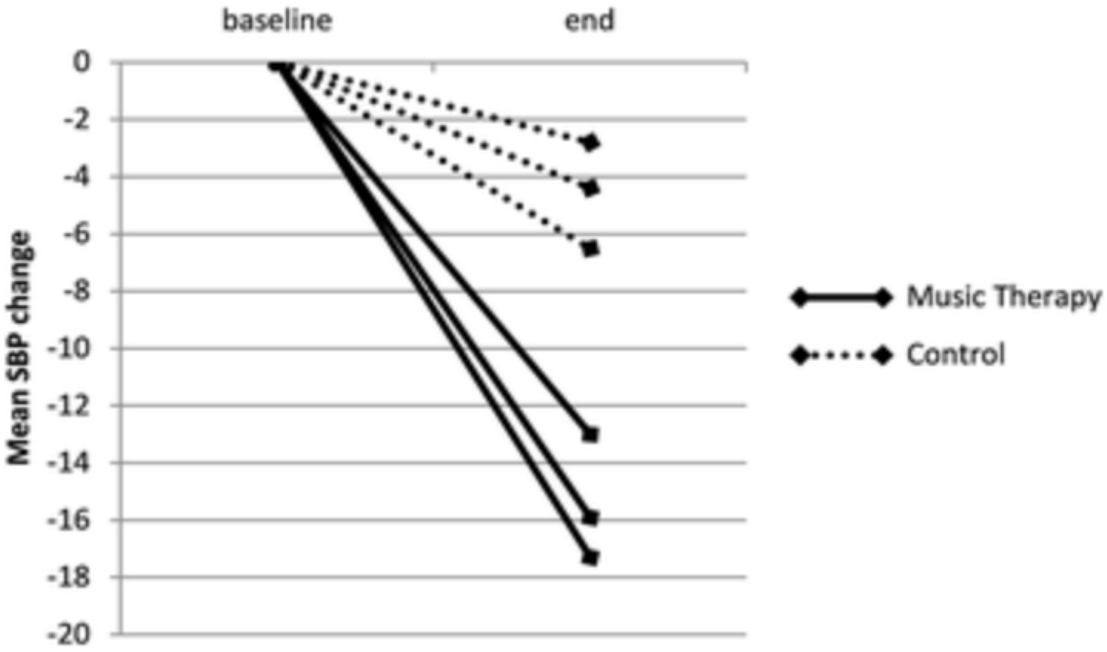

Figure 2: from review by Kuehlmann et al., BMC Cardiovascular Disorders (2016) 16:69

REFERENCES

1. Bernardi L, Porta C, Sleight P. Cardiovascular, cerebrovascular, and respiratory changes induced by different types of music in musicians and non-msicians: the importance of silence. Heart 2006; 9: 445–452. DOI: 10.1136/hrt.2005.064600

2. Chafin S, Roy M, Gerin W, Christenfeld N. Music can facilitate blood pressure recovery from stress. Br J Health Psychol. 2004 Sep;9(Pt 3):393-403. DOI: 10.1348/1359107041557020

3. Daiber A, Kroeller-Schön S, Oelze M, Hahad O, Li H, Schulz R, Steven S, Muenzel T. Oxidative stress and inflammation contribute to traffic noise-induced vascular and cerebral dysfunction via uncoupling of nitric oxide synthases. Redox Biol. 2020 Apr 20:101506.. doi: 10.1016/j.redox.2020.101506.

4. Fogari R, Zoppi A, Vanasia A et al. Occupational noise and blood pressure. J Hyp 1994; 12: 475–479

5. Holst GJ, Paarup HP, Baelum J. A cross-sectional study of psychosocial work environment and stress in the Danish symphony orchestras.Int Arch Occup Eviron Health 2011; 85,6: 639–649. doi: 10.1007/s00420-011-0710-z

6. Koelsch, Stefan; Jaencke, Lutz. Music and the heart. European Heart Journal 2015, 36(44):3043-3049. doi: 10.1093/eurheartj/ehv430

7. Kuehlmann AY, Etnel JR, Roos-Hesselink JW, Jeekel, . Bogers AJ, Takkenberg JJ. Systematic review and meta-analysis of music interventions in hypertension treatment: a quest for answers. BMC Cardiovascular Disorders (2016) 16:69. doi: 10.1186/s12872-016-0244-0

8. Mulcahy D, Keegan J, Fingret A. Circadian variation of heart rate is affected by environment: a study of continuous electrocardiographicmonitoring in members of a symphony orchestra. Heart 1990; 64:388–392. doi: 10.1136/hrt.64.6.388

9. Paul M. Death of the conductor – cardiovascular deaths on orchestra podium and opera stage. Dtsch Med Wochenschr 2012;13700: 2712–2714. doi: 10.1055/s-0032-1327363

10. Sutoo D; Akiyama K. Music improves dopaminergic neurotransmission: demonstration based onthe effect of music on blood pressure regulation. Brain Research 2004; 1016, 255–262. doi: 10.1016/j.brainres.2004.05.018

11. Schmidt JH, Pedersen ER, Juhl PM et al. Sound exposure of symphony orchestra musicians. Ann Occup Hyg 2011; 55,8: 893–905. doi: 10.1093/annhyg/mer055

12. Zeeb H, Hegewald J, Schubert M, Wagner M, Droege P, Swart E, Seidler A. Traffic noise and hypertension - results from a large case-control study. Environ Res. 2017; 157:110-117. doi: 10.1016/j.envres.2017.05.019