*Full-Length Article*

# Differential effects of Bach's Orchestral Suite No. 3 on Blood Pressure and Heart rate: *A Prospective Controlled Study*

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## Abstract

**Background** There is little known about whether or not music of varying styles can directly alter blood pressure (BP) and heart rate (HR) in humans. We studied the potential effects of Bach's orchestral Suite No. 3 in comparison to silence (S [controls CO]) on BP and HR.

**Objective** To analyze the effect of different music styles (intervention group) on BP, HR, S compared to S (control group).

**Method** 120 volunteers aged 25-75 years were randomly assigned in the intervention group (n=60) or to a control group (n=60). Interventional music styles were the different parts of Bach's Suite No. 3, BWV 1068 [Overture, Air, Gavotte, Bourrée, Gigue]). 60 healthy volunteers served as a control group (CO): they underwent an identical study protocol but without music application.

**Results** In studied volunteers, systolic, diastolic BP (mm Hg) and HR ($min^{-1}$) decreased when Bach was played compared to CO ($p<0.001$). Prior to the study $BP_{syst}$ was 128.3±11.3 mm Hg, $BP_{diast}$ was 81.9±7.9 Hg and HR was 75.3±12.0 bpm. After sound exposure or in CO the following results were observed (table). *$p<0.001$, [a]$p=0.01$, [b]$p=0.08$

| | $BP_{syst}$ (mm Hg) | $BP_{diast}$ (mm Hg) | HR ($min^{-1}$) |
|---|---|---|---|
| Overture | 120.9±12.4* | 76.9±8.8* | 69.8±11.2* |
| Air | 121.1±12.4* | 77.1±7.9* | 68.4±9.4* |
| Gavotte | 120.9±12.6* | 77.0±8.9* | 68.5±9.8* |
| Bourrée | 120.6±13.7* | 76.5±9.4* | 66.4±8.4* |
| Gigue | 120.4±15.2* | 78.5±11.1* | 68.1±9.2* |
| Controls | 120.6±8.7[a] | 75.4±5.5[b] | 78.8±11.9* |

**Conclusions** The results provide clear evidence for the potential of Bach' music styles to influence cardiovascular parameters. All parts of the Suite No. 3 lead to decreased values of BP and HR. In the control group we could not observe similar findings.
**Trial registration** German Clinical Trials Register (DRKS00009835)

**Keywords:** ***Johann Sebastian Bach, Suite No. 3 (BWV 1068), blood pressure, heart rate, cortisol.***

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## Introduction

Music can enhance cognitive function, attention, memory and is associated with modulation in heart rate, heart rate variability, blood pressure, body temperature, perspiration and respiration (1-6). Listening to classical music may prove helpful for verbal learning during early development and in educational settings (7-9). Music's effects on the brain's electrophysiology have been reported in a number of studies (10-12). Recently, some studies analyzed the effects of music on different cardiovascular parameters (13-16).

## Methods

*Trial design*

This prospective randomized study was comprised of a study population with healthy volunteers compared to controls. In studied volunteers, all were sequentially subjected to Bach's Suite No. 3, D major (BWV 1068) and were compared to periods of silence (control group). The study was approved by the Ethics committee, of the Ruhr-University Bochum, and all volunteers provided written, informed consent to participate (Register-Nr. 3898-11). The study has been registered by the German Clinical Trials Register (DRKS00009835).

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Hans-Joachim Trappe, MD, FACC, FESC Address: Hoelkeskampring 40, 44625 Herne, Germany E-mail: hans-joachim.trappe@t-online.de | COI statement: The authors declared that no financial support was given for the writing of this article. The authors have no conflict of interest to declare.

**Trial registration:** German Clinical Trials Register (DRKS00009835)

*Participants*

Inclusion criteria for the volunteers were a normal physical examination, an age range between 25 to 75 years, no history of any cardiac disease, no hypertension and a normal 12 lead electrocardiogram (17). None of the volunteers were taking any kind of medication. Volunteers with systolic blood pressures of >140 mm Hg or diastolic blood pressures > 90 mm Hg at the physical examination prior to the study, were excluded.

*Studied music and measurements*

The Suite No. 3 from Johann Sebastian Bach (1685-1750) consisting of five parts: "Overture", "Air", "Gavotte", "Bourrée" and "Gigue." The duration of the Suite is 21 minutes. Studies were performed in all participants on consecutive days with each intervention starting every day at 10.00 a.m. in the same room. All volunteers were instrumented with a 12-lead surface electrocardiogram (GE Marquette MAC 1200), a Holter recording (PhysioQuant, Fa. Envitec), and a continuous blood pressure recorder (Pathfinder-system, Fa. Spacelab Healthcare) or the Lifecard CF system, Fa. DelMar Reynolds GmbH. In all participants, after a baseline silence period of 30-45 min, study music was presented via stereo headphones (Fa. Philips, Einthoven, The Netherlands) plugged into an mp3-player (Odays S-8 2 GB, S-15, Fa. Odys). The volume level of the music interventions was maintained at 60 db throughout. Over the course of the experiment, subjects were in a supine position. During the baseline period the subjects were asked to close their eyes and concentrate on the music. Room temperature was 23° C.

*Statistical analysis*

Paired sample t-tests were performed to evaluate differences between measurements taken before and after listening to music or silence. The Wilcoxon's test and Mann-Whitney-U test were applied to determine the differences before, during, and after listening to music or silence due to non-normally distributed data. Other tests used were the Shapiro-Wilk-test and the Bowkers test. All analyses were done with IBM-SPSS, Version 20 (IBM, Munich, Germany). P-values less than 0.05 were considered significant.

## Results

*Study population and Controls*

60 healthy volunteers (30 males, 30 females) with a mean age of 46.1±12.6 years (range 25-75 years) were included in this prospective randomized study. These participants listened to the 5 different parts of Bach's Suite. 60 other volunteers (30 males, 30 females) with a mean age of 44.7±13.8 years (range 25-75 years) served as controls. There were no significant clinical differences between both groups (Table 1).

**Table 1** Demographics in the study population and controls

| | Study group | Controls | p |
|---|---|---|---|
| No of volunteers | 60 | 60 | ns |
| Mean age (yrs) | 46.1±12.6 | 44.7±13.8 | ns |
| Mean height (cm) | 173.6±10.8 | 173.1±9.7 | ns |
| Weight (kg) | 76.7±18.4 | 74.4±16.1 | ns |
| BMI (kg/m$^2$) | 25.2±4.5 | 24.6±3.8 | ns |
| RR syst (mm Hg) | 128.3±11.3 | 123.0±11.2 | ns |
| RR diast (mm Hg) | 81.9±7.9 | 77.4±7.9 | ns |
| Heart rate (bpm) | 75.3±12.0 | 70.4±14.0 | ns |
| **males** | | | |
| No of volunteers | 30 | 30 | ns |
| Mean age (yrs) | 45.4±13.3 | 45.5±13.7 | ns |
| Mean height (cm) | 181.7±8.2 | 180.4±6.9 | ns |
| Weight (kg) | 87.5±17.7 | 85.2±15.1 | ns |
| BMI (kg/m$^2$) | 26.4±4.7 | 26.2±4.1 | ns |
| RR syst (mm Hg) | 129.9±12.3 | 129.7±9.0 | ns |
| RR diast (mm Hg) | 79.4±7.4 | 80.3±6.3 | ns |
| Heart rate (bpm) | 71.9±12.9 | 68.6±10.8 | ns |
| **females** | | | |
| No of volunteers | 30 | 30 | ns |
| Mean age (yrs) | 46.7±12.0 | 43.9±14.0 | ns |
| Mean hight (cm) | 165.6±6.1 | 166.3±6.6 | ns |
| Weight (kg) | 65.8±11.6 | 64.4±9.1 | ns |
| BMI (kg/m$^2$) | 24.0±4.1 | 23.3±2.8 | ns |
| RR syst (mm Hg) | 124.7±12.3 | 120.1±14.4 | ns |
| RR diast (mm Hg) | 80.2±8.1 | 79.4±6.4 | ns |
| Heart rate (bpm) | 66.0±13.6 | 68.7±9.5 | ns |

*BMI=body mass index, cm=centimeter, bpm=beats per minute, diast=diastolic, kg=kilogram mm=millimeter, syst=systolic, RR= blood pressure (Riva-Rocci), yrs=years*

*Study measurements*

At 10.00 a.m., just prior to the music interventions, the volunteers underwent a blood test to measure their cortisol level to evaluate their stress level. 10 o'clock was chosen because, at this time, the circadian cortisol level is typically at its lowest. After the end of each music intervention, another blood test for cortisol measurement was performed. Just before and just after, participants were exposed to each music intervention, their blood pressure and heart rate were recorded under silence. Then, the music started and blood pressures and heart rates were recorded during 60 min after starting every 5 minutes. After one hour, measurements were taken every 15 min until 1.00 p.m ("activity" after music application). All participants were asked to answer a questionnaire regarding music behavior. Structured interviews verified that the subjects had no formal or informal music training.

*Cortisol measurements*

The cortisol level for the study population at baseline was 12.4±5.3 µg/ml (range 6.0-31.8 µg/ml) and was not different between males (13.1±5.1 µg/ml, range 6.0-24.9 µg/ml) and females (11.8±5.5 µg/ml, range 6.0-31.8 µg/ml). In addition no significant differences were observed between volunteers < 50

years (12.0±5.3 µg/ml, range 6.0-24.9 µg/ml) and those ≥ 50 years (12.9±5.4 µg/ml, range 6.0-31.8 µg/ml). Cortisol levels decreased significantly compared to baseline when listening to Bach's music (10.3±4.6 µg/ml, range 7.0-23.7 µg/ml, p<0.001). Cortisol level also decreased significantly in the control population when exposed to silence (12.2±4.5 µg/ml, range 3.6-27.7 µg/ml, p<0.001).

*Blood pressures in general*

Upon the intervention of Bach's music, systolic blood pressure significantly reduced from 128.3±11.3 mm Hg, range 107-138 mm Hg, just before the music to 120.8±12.6 mm Hg, range 100-163 mm Hg, p<0,001, just after the music. After the end of the classical music, systolic blood pressure increased significantly (mean 125.0±12.2 mm Hg, range 105-160 mm Hg, p<0,001). Likewise, significant reductions were noted in diastolic blood pressure immediately following classical music from 81.9±7.9 mm Hg, range 61-94 mm Hg just before the music to 77.0±9.0 mm Hg, range 55-101 mm Hg, p<0,001, just after the music. After the end of Bach's music the diastolic blood pressure was significantly higher (mean 82.7.0±8.4 mm Hg, range 58-102 mm Hg) compared to music application (p<0,001)(Fig. 1,2).

*Figure 1*

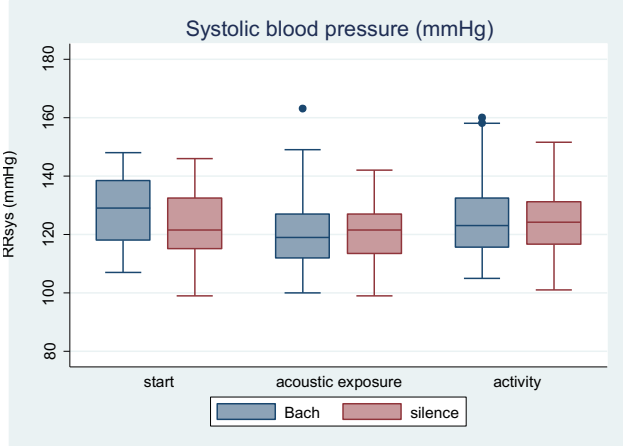
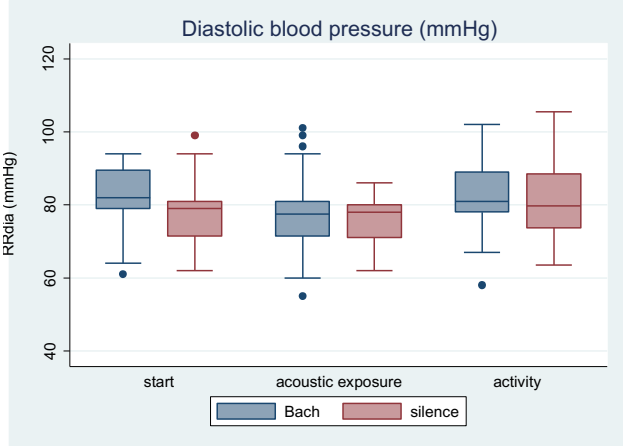



*Figure 2*




*Blood pressures in different styles of the Suite*

Baseline systolic blood pressures (128.3±11.3 mm Hg, range 107-148 mm Hg) decreased significantly following "Overture" (120.9±12.4 mm Hg, range 97-153 mm Hg, p<0.001), "Air" (121.1±12.4 mm Hg, range 98-162 mm Hg, p<0.001), "Gavotte" (120.9±12.6 mm Hg, range 102-164 mm Hg, p<0.001), "Bourrée" (120.6±13.7 mm Hg, range 95-165 mm Hg, p<0.001) and "Gigue" (120.4±15.2 mm Hg, range 86-162 mm Hg, p<0.001)(Fig. 3). In addition, significant differences were observed in diastolic blood pressures: prior to the classical music diastolic blood pressure was 81.9±7.9 mm Hg (range 61-94 mm Hg) and decreased significantly during "Overture" (76.9±8.8 mm Hg, range 50-100 mm Hg, p<0.001), "Air" (77.1±7.9 mm Hg, range 53-95 mm Hg, p<0.001), "Gavotte" (77.0±8.9 mm Hg, range 56-101 mm Hg, range 56-103 mm Hg)(p<0.001), "Bourrée" (76.5±9.4 mm Hg, range 55-103 mm Hg, p<0.001) and "Gigue" (78.5±11.1 mm Hg, range 56-105 mm Hg, p<0.001)(Fig. 4).

*Figure 3*

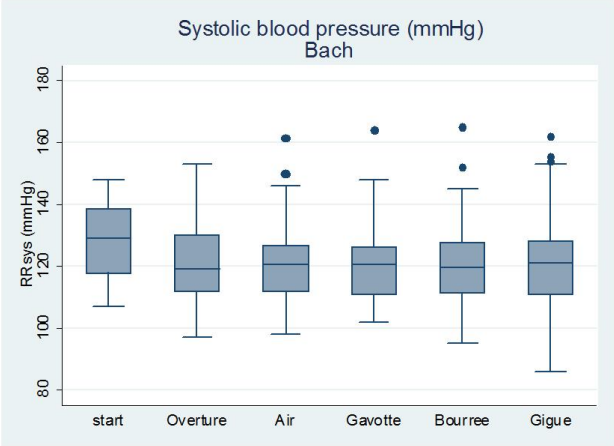
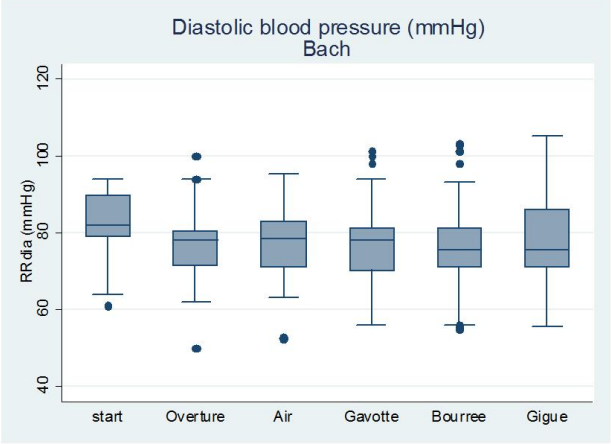



*Figure 4*



Controls

Similar effects on blood pressures were observed in the control group: significant differences were noted in systolic blood pressure before to after silence (123.0±11.2 mm Hg, range 99-146 mm Hg) to 120.6±8.7 mm Hg, range 100-163 mm Hg, p=0.016. After the end of silence time the systolic blood pressure increased significantly (124.4±10.9 mm Hg, range 101-152 mm Hg, p<0,001). In addition, similar differences were noted in diastolic blood pressure before and during silence (77.4±7.9 mm Hg, range 62-99 mm Hg) before and after (75.4±5.5 mm Hg, range 55-101 mm Hg)(p=0.081). After the end of silence study time the diastolic blood pressure was significantly higher (81.3.0±9.7 mm Hg, range 64-106 mm Hg) compared to music listening application (p<0,001).

*Heart rate*

Significant differences were noted in heart rate from the baseline period before the Bach music intervention (heart rate 75.3±12.0 bpm, range 55-90 bpm) to following it (heart rate 67.8±8.4 bpm, range 53-86 bpm, p<0,001). After the end of Bach's music, heart rate increased significantly to 78.4±11.9 bpm, range 58-113 bpm, p<0.001 (Fig. 5). Analyzing the effect of the different components of the Bach Suite, heart rate prior to its commencement was 75.3±12.0 bpm, range 55-99 bpm. From this, heart rate went to 69.8±11.2 bpm, range 48-105 (p<0,001) during "Overture", 68.4±9.4 bpm, range 53-88 bpm (p<0.001) during "Air" 68.4±9.4 bpm, range 53-88 bpm (p<0.001), during "Gavotte" 68.5±9.8 bpm, range 51-88 bpm (p<0.001), during "Bourrée" 66.4±8.4 bpm, range 51-82 bpm (p<0.001) and during "Gigue" 68.1±9.2 bpm, range 52-85 bpm (p<0.001)(Fig. 6).

The control group exhibited similar changes: heart rate was 70.4±14.0 bpm (range 52-139 bpm) at the beginning, 64.6±7.6 bpm, range 48-82 bpm (p<0.001) during silence and 78.8±11.9 bpm, range 49-101 bpm (p<0.001) after.

*Figure 5*

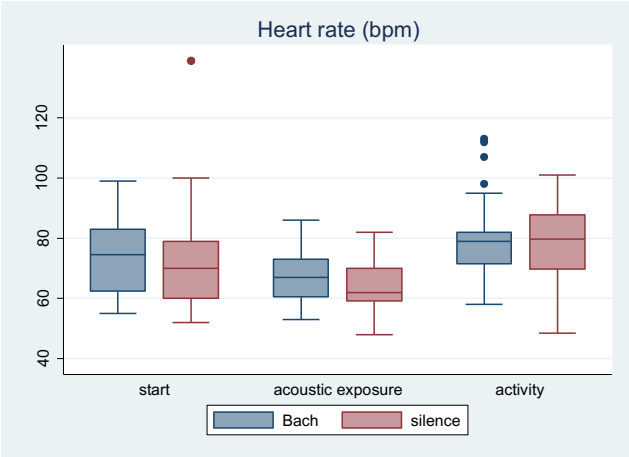
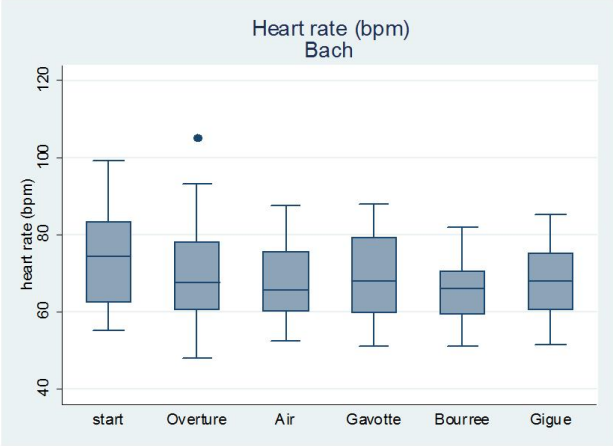



*Figure 6*




**Discussion**

There are several studies who analyzed the effect of music on the cardiovascular system (6, 19-23) Classical music can enhance cognitive functions, such as spatiotemporal reasoning, attention and memory (24-26). In the present study, music by Bach was selected to compare different "Bach styles" on their effects on blood pressure and heart rate. Analyzing the results from the five individual parts of the Suite No. 3, significant differences were not demonstrated despite differences in the loudness and tempo of the different components. This is in contrast to prior observations which have concluded that the structure of a piece of music has a constant dynamic influence on cardiovascular and respiratory responses correlating with musical profile (6,27). Specific musical phrases (frequently at a rhythm of 6 cycles/min) have been shown to 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 (28). These observations were made during short music applications (10 second periods).

**Influence of music and silence on cortisol level**

Nielsson et al. (29) analyzed the follow-up of 58 patients following cardiac surgery. These patients underwent musical therapy (30 min music exposure one day after surgery) compared to controls. Cortisol level, heart rate, ventilation rate, blood pressure, $SaO_2$, pain and anxiety indices were assessed. They found significantly lower cortisol levels in the music group patients compared to those without music. There were no significant differences in heart rate, blood pressure, respiration and oxygen saturation between both groups. Similar effects have been reported by Antonietti in patients

undergoing rehabilitation following surgery (30). In our study, we also demonstrated that cortisol levels decreased during music application. However, in our study both groups (exposed to music as well as exposed to silence) experienced a fall in their cortisol levels. It seems possible that much of the observed effects were the result of sitting still. Further studies may confirm or exclude these observations. In addition, further studies should evaluate whether the positioning of music listening (lying, standing) both in the "music group" and the "silence group" may play a role. In the present study the music of Bach's Suite resulted in lowered blood pressure and heart rate, while listening to music in a lying position and listening to music resulted in a notable lowering of serum cortisol concentrations, whereas rest alone (control group) had only a small effect on cortisol levels.

**Listening habits and musical sensibilities**

All subjects were asked what their listening habits and musical sensibilities were. Any association of musical genres of Bach's Suite, listening habits (never, rarely, occasionally, often, regularly, daily), and measured values did not show statistically significant effects. Therefore, we could exclude that a familiarity with Bach's Suite was in part responsible for the observed effects. No association was found between musical genres (different pieces of the Suite), changes to blood pressure and heart rate, and subjects' listening habits.

## Conclusions

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 has significant effects on the cardiovascular system. In the present study we demonstrated that different music styles in Bach's famous Suite No. 3 decreased blood pressures and heart rate significantly. This analysis is part of a study published elsewhere (31). The results of the present study and of another study (32) may have many implications for both cardiology and general medicine as pointed out recently (33).

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## Biographical Statements

Hans-Joachim Trappe, born 1954, is a cardiologist, professor for internal medicine and cardiology at the Ruhr-University Bochum, Germany. Since 1996 he is director of the department of cardiology and angiology, Marien Hospital Herne, University Hospital of the Ruhr-University, Bochum, Germany. Beside his work in internal medicine and cardiology, he is an international organ player with many years of experience, with concerts in Cologne, Salzburg, Paris, Jerusalem, Berlin, Vatican, etc. He has recorded 27 CDs as an organ player.

Irini Maria Breker has been working with Prof. Trappe for many years. She was a cardiologist in the department of cardiology and angiology at the Marien Hospital Herne, RuhrUniversity of Bochum. Since January 2018 she is working in the Marien Hospital Herne, Department „MVZ", Germany.