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Immediate physiological responses of healthy volunteers to different types of music: cardiovascular, hormonal and mental changes

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Abstract. A group of 20 healthy volunteers [10 women, 10 men; median age 25 (20–33) years] were examined by means of pulsed wave Doppler echocardiography, blood sample analysis and psychological testing before and after listening to three different examples of music: a waltz by J. Strauss, a modern classic by H. W. Henze, and meditative music by R. Shankar. To assess small haemodynamic changes, mitral flow, which reflects left ventricular diastolic behaviour, was measured by Doppler ultrasound. Heart rate, arterial blood pressure and plasma concentrations of adrenocorticotropic hormone, cortisol, prolactin, adrenaline, noradrenaline, atrial natriuretic peptide (ANP) and tissue plasminogen activator (t-PA) were determined simultaneously. Transmitral flow profile is characterized by early E-wave and late atrial induced A-wave. Velocity-time integrals were measured and the atrial filling fraction was calculated. The mental state was measured by using a psychological score (Zerssen) with low values (minimum 0) for enthusiastic and high values (maximum 56) for depressive patterns. Music by J. Strauss resulted in an increase of atrial filling fraction (AFF; 29% vs 26%; $P<0.05$) and ANP (63 $pg \cdot ml^{-1}$ vs 60 $pg \cdot ml^{-1}$; $P<0.05$). The mental state was improved (Zerssen: 6.5 vs 11 points; $P<0.05$). After the music of H. W. Henze prolactin values were lowered (7.7 $ng \cdot ml^{-1}$ vs 9.1 $ng \cdot ml^{-1}$; $P<0.01$). The music of R. Shankar led to a decrease of cortisol concentrations (57 $ng \cdot ml^{-1}$ vs 65 $ng \cdot ml^{-1}$; $P<0.001$), noradrenaline concentrations (209 $\mu g \cdot l^{-1}$ vs 256 $\mu g \cdot l^{-1}$; $P<0.01$) and t-PA antigen concentrations (1.1 $ng \cdot ml^{-1}$ vs 1.4 $ng \cdot ml^{-1}$; $P<0.05$). Heart rate and blood pressure remained unchanged during the whole experiment. We concluded that different types of music induced changes of left ventricular diastolic function and plasma hormone concentrations. After rhythmic music (Strauss) AFF and ANP increased significantly, the mental state being improved. Meditative music (Shankar) lowered plasma cortisol, noradrenaline and t-PA concentrations; the observed increase of early left ventricular filling was not statistically significant. Prolactin concentrations decreased after modern music (Henze). Thus, it would seem to be possible to detect cardiovascular changes following different types of music by Doppler ultrasound and hormone analysis, meditative music having promising therapeutic implications in the treatment of conditions of stress.

Key words: Doppler mitral flow – Left ventricle – Diastolic function – Noradrenaline concentrations – Effects of music

Introduction

> "And will not our musician, pursuing the same trail in his use of gymnastics, if he please, get to have no need of medicine save when indispensable" (Plato, reprint 1963)

Music has been thought to be an effective agent in medical treatment since ancient times (Pratt and Jones 1987). A large number of studies have been performed, investigating many questions from the fields of medical, psychological and other sciences (Spintge and Droh 1992) and although reference has been made to cardiovascular aspects, there is less data on acute haemodynamic responses to music. The simultaneous determination of hormonal and cardiovascular changes with respect to the acute mental state of participants has not been described in the literature up to now.

It is known that one of the first detectable signs of various heart diseases is an impaired diastolic function of the left ventricle (LV) (Nishimura et al. 1989b). It has been shown that the diastolic function of the LV

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can be estimated from Doppler measurement of mitral blood flow (Kitabatake et al. 1982; Rokey et al. 1985; Nishimura et al. 1989a, b) as has been performed in the present study. The cardiovascular system is predominantly influenced by rhythmic processes such as the heart beat. Although beat-to-beat variability can always be seen in healthy people, a stable heart rhythm is a condition of health (Appel et al. 1989). Why there is physiological variability is not yet completely understood. Thus we selected three examples of music which differed in their rhythmic characteristics. Firstly, we chose a waltz by J. Strauss which has a regular rhythm. Secondly, in contrast we used a piece by H. W. Henze with an irregular rhythm (Henze 1984). The third piece of music was of Indian origin by R. Shankar. This kind of music is sometimes called meditative and not rhythmic. The actual mental state of the volunteers was assessed by a psychometric score (Zerssen; Leuwer 1987).

Important stress-released hormones, effective in the cardiovascular system, such as adrenaline, noradrenaline, cortisol and adrenocorticotropic hormone (ACTH), atrial natriuretic peptide (ANP) and prolactin have been simultaneously determined as a means of understanding the acute haemodynamic and hormonal effects of music. In addition, tissue plasminogen activator (t-PA) has been assessed with the intention of applying music to coronary patients, since the fibrinolytic system has been found to play an important role in the pathogenesis of atherosclerosis and its prevention by physical activity (Molz et al. 1993; Röcker 1993).

Classical Greek philosophy has shown us that music and sports are two fundamental aspects of health [Plato (reprint) 1963]; perhaps our present work may once again demonstrate the importance of music. The aim of this study therefore was to detect the immediate haemodynamic responses to different types of music, the concurrent variations of important hormones and the mental state of healthy volunteers. The evaluation of possible beneficial effects of different types of music could lead to further studies of patients suffering from cardiovascular diseases as well as to therapeutic trials with specific types of music based on physiological data.

Methods

Subjects

A group of 20 healthy volunteers (10 women, 10 men) with a median age of 25 (20–33) years agreed to participate in the study and gave written informed consent. The volunteers were students from the local medical school, some nurses and some students of nonmedical subjects and all of them had at least a high school education. None of them were taking any medication; 6 were cigarette smokers. Further characteristics of the participants are shown in Table 1.

Table 1. Characteristics of the 20 participants (10 women, 10 men)

Parameter	Median (25%-/75%-percentiles)	Range
Age (years)	25 (23.25/27.5)	20–33
Heart rate (beats·min^{-1})	70.5 (58.5/79.5)	56–88
RR_{sys} (mmHg)	120 (110/130)	105–145
RR_{dia} (mmHg)	70 (55/85)	55–85
BSA (m^2)	1.77 (1.58/1.96)	1.46–2.22
LV mass index (g·m^{-2})	61.2 (49.7/68.3)	35.9–91.6

RR_{sys}, Systolic blood pressure; RR_{dia}, diastolic blood pressure; BSA, body surface area; LV, left ventricular

Music

The three examples of music were:
1. A part of "Rosen aus dem Süden" by Johann Strauss, duration 6 min 43 s, peak sound intensity 68 dB (at 1000 Hz).
2. "Viertes Streichquartett, 4. Satz: Rondo improvisato" by Hans Werner Henze, duration 6 min 4 s, peak sound intensity 73 dB (at 1000 Hz).
3. A part of "Raga Ramdas Malhar" by Ravi Shankar, duration 6 min and 25 s, peak sound intensity 70 dB (at 1000 Hz).

The music was listened to on closed headphones. Sound intensity was selected by a professional musician so that everyone would have to concentrate on the music. Afterwards, sound intensity was measured using a Klark DN 60 real-time spectrum analyser and a Neumann K11-140 microphone. As the threshold at which music cannot be negotiated lays approximately at 65 phon (phon = dB at 1000 Hz; Harrer 1982) we accepted the level of the sound intensity as given above.

Hypothesis

According to the character of the different types of music, we hypothesized that Strauss would cause some stress and Shankar would lower stress. Henze could have multiple effects because of its demanding characteristics.

Experimental procedure

Protocol. Investigations were performed between 2 p.m. and 8 p.m.; participants were advised not to eat, smoke or drink anything but water 1 h prior to the measurements. The six possible sequences of the three examples of music were randomly assigned to each of the volunteers, who were advised not to talk about the music during the investigation. The observer of the echocardiographic measurements and the laboratory staff were blinded to the sequence of music. Measurements were performed in the following sequence:
1. Insertion of an intravenous cannula, positioning of the participant in a supine position, and instruction as to the local conditions were effected in the 10-min rest period.
2. Basic echocardiographic examination.
3. Blood sample.
4. Zerssen score (pre-test).
5. Music.
6. Assessment of Doppler mitral flow and blood sample; simultaneous measurement of heart rate (monitor) and blood pressure (Riva Rocci).
7. Zerssen score (post-test).
8. Rest for 5 min.