Original Article

Effects of Music Therapy on Heart Rate Variability in Elderly Patients with Cerebral Vascular Disease and Dementia

Akira Kurita MD*[1], Bonpei Takase MD*[2], Kaoru Okada MD*[3], Yuji Horiguchi MD*[1], Shinya Abe MD*[4], Yoshiki Kusama MD*[3], Hirotsugu Atarasi MD*[3]

*[1]Sanai Hospital, Tokyo
*[2]National Defense Medical College, Saitama
*[3]Nippon Medical School, Tamanagayama, Tokyo
*[4]Kumegawa Hospital, Tokyo

Objective: In Japan, the number of elderly people with cerebral vascular disease (CVD) and dementia is increasing, resulting in increased expenditures to treat such patients. Reports indicate that music therapy can reduce anxiety in patients with myocardial infarction. However, it is unclear whether music therapy can have beneficial effects on very elderly patients with CVD and dementia, as these conditions may influence cardiac autonomic nerve functions. Therefore, we investigated the effects of music therapy on the autonomic nerve system in elderly patients with CVD and dementia, using an ambulatory Holter ECG system.

Methods and Results: The subjects were 12 elderly patients aged $\geq$75 years, hospitalized for CVD and dementia. We measured their heart rate variability (HRV) indices of power domain and frequency domain analysis. The mean RR significantly increased during music therapy, from 842 ± 174 to 1022 ± 284 ($p < 0.05$), and decreased to 820 ± 284 ms after music therapy. HF significantly increased during music therapy, from 59 ± 41 to 127 ± 97 ms^2 ($p < 0.01$), and decreased to 77 ± 60 ms^2 after music therapy. LF/HF decreased from 2.2 ± 1.3 to 1.7 ± 1.3 during music therapy ($p < 0.10$), and increased to 2.0 ± 1.1 after music therapy. Time domain (HRV) indices increased during music therapy and decreased after music therapy: RMSSD increased from 19.4 ± 11 to 39.8 ± 17 ms, and then decreased to 19.4 ± 8.3 ms; pNN50 increased from 3.6 ± 3.2 to $16.1 \pm 13.3\%$ ($p < 0.01$), and then decreased to $4.3 \pm 4.2\%$.

Conclusions: Music therapy enhanced parasympathetic activity and decreased sympathetic activity in elderly patients with CVD and dementia. These findings suggest that music therapy is useful for alleviating anxiety, increasing comfort and facilitating relaxation for elderly patients with CVD and dementia.
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Key words: Heart rate variability, Music therapy, Cerebral vascular disease, Dementia

Introduction

Studies in several countries have demonstrated that music therapy can improve mood states and reduce anxiety in patients in coronary care units, and have shown that music therapy can help maintain

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Address for correspondence: Akira Kurita MD, Sanai Hospital, 1-20-22 Matsubara, Setagaya-ku, Tokyo 156-0043, Japan
E-mail: a-kurita@msi.biglobe.ne.jp

cardiac autonomic balance after acute myocardial infarction.[1–7] In healthy adolescents, relaxing music can significantly reduce heart rate and heart rate variability (HRV),[8] which are among the most widely used indicators in studies of cardiac autonomic modulation.[9] However, it is unclear whether music therapy can significantly affect the function of the autonomic nervous system in elderly patients after cerebral vascular accidents. The elderly population of Japan is rapidly increasing, because Japan has the world's longest average life expectancy for both genders, and the birth rate of Japan is decreasing.[10] In 2025, people older than 65 years will comprise approximately 25% of the population of Japan.[10] Consequently, the incidence of cerebral vascular disease (CVD) and dementia is increasing.

Previous studies do not clearly indicate whether music can have significant beneficial mental effects on elderly patients with CVD and dementia. The purpose of the present study was to examine the effects of music on the relaxation response in elderly patients with CVD and dementia.

Methods

The subjects were 12 elderly patients (4 male and 8 female; age range, 80–101 years) who were hospitalized at Sanai Hospital in Hachioji City, Tokyo for CVD and dementia. Patients with acute inflammatory disease, myocardial infarction, cancer or any other acute illness were excluded. The study was conducted in part of daily cares and in accordance with the principles of the Helsinki Declaration.

All subjects underwent a uniform structured clinical evaluation including medical history, neurological examination, cognitive function assessment, interview, and standard serum blood laboratory tests. Also, all subjects underwent a chest X-ray, ECG, and computed tomography (CT) of the brain. Diagnosis of dementia was made by consensus at a conference of physicians, nurses and care workers, and was based on results of the Mini-Mental State Examination (possible score range, 0 to 30; dementia indicated by scores < 24[11]). Pre-existing medication (1 patient on nifedipine, 2 on diuretics, 2 on sedatives and 3 on aspirin) was continued throughout the study. None of the patients were taking beta-blockers.

Blood samples were collected in an early fasting state. Plasma glucose concentration and serum concentrations of total cholesterol, triglyceride and high-density lipoprotein were analyzed using an automated enzymatic method.

Table 1 Characteristics of subjects.

Age:	88 ± 12 years
Gender ratio (male/female):	4/8
Body mass index:	20 ± 3 kg/m^2
Mini-Mental State Examination score:	17 ± 6 patients
Types of Diet Tube feeding:	7/12 patients
Hemiplegia:	7/12 patients
Disuse syndrome:	5/12 patients
Brain CT:	
Typical low density area:	8/12 patients
Lacunar infarction:	4/12 patients
Systolic blood pressure:	110 ± 22 mm/Hg
Diastolic blood pressure:	80 ± 15 mm/Hg
Total Cholesterol:	208 ± 20 mg/ml
Triglycerides:	108 ± 15 mg/ml

All non-ratio values are mean ± SD.

Music therapy was administered by 2 licensed music therapists from 11.00 to 11.30 am. The music therapy consisted of famous old Japanese nursery rhymes, folk songs and hymns, and recently popular Japanese music. ECG recordings were made using the Holter device for at least 30 minutes before music therapy, during music therapy, and for at least 2 hours after music therapy. The ECG data were recorded using two-channel leads, and 1 of 2 different Holter recording systems: a Nihonkohden (DMC-4502) system or a Fukuda Denshi (FMD-150) recording system. Spectral power results were obtained from the first 2-minute segments with a total spectrum of 128 points and frequency ranging from 0.01 to 1.0 Hz. The low-frequency (LF) band (0.04 to 0.15 Hz), the high-frequency (HF) band (0.15 to 0.40 HZ) and the power values were calculated using GMS software.[12] The LF and HF components were expressed as power, and were measured as ms^2. The HF component mainly reflects parasympathetic activity, whereas the LF/HF mainly reflects sympathetic activity and sympathovagal balance.[9] For time domain analysis, we used SD, pNN50SD and RMMSD: SD equals standard deviation of 5-minute means for all R-to-R (RR) intervals (R wave amplitude of ECG) during the entire recording period; pNN50SD equals percentage of successive RR-interval differences $\geq$50 ms; and RMMD equals square root of the mean of the sum of the squares of differences between adjacent intervals. These parameters were used to express parasympathetic activity.[9]

Results were expressed as mean ± SD. Two-way

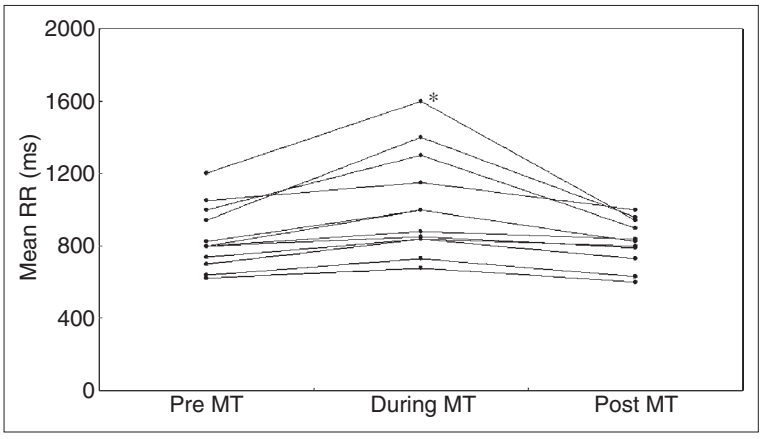

Figure 1 Changes in mean RR.
The mean RR significantly increased during music therapy, from 842 ± 174 to 1022 ± 284 ms ($p < 0.05$), and had decreased to 820 ± 284 ms at 2 hours after the end of music therapy.
MT: music therapy, *: $p < 0.05$

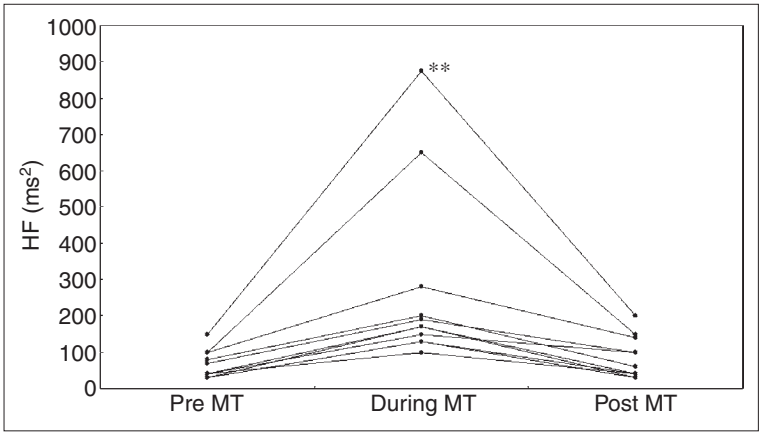

Figure 2 Changes in HF.
HF significantly increased during music therapy, from 59 ± 41 to $127 \pm 97\,ms^2$ ($p < 0.01$), and had decreased to $77 \pm 60\,ms^2$ at 2 hours after the end of music therapy.
**: $p < 0.01$

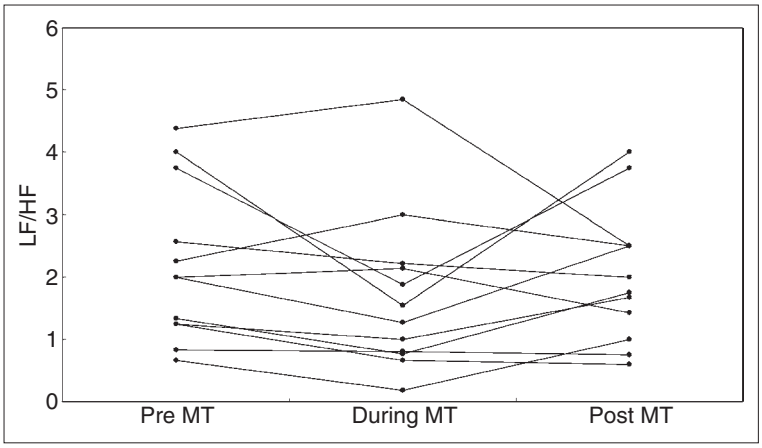

Figure 3 Changes in LF/HF.
LF/HF decreased from 2.2 ± 1.3 to 1.7 ± 1.3 ($p < 0.1$) during music therapy, and had increased to 2.0 ± 1.1 at 2 hours after the end of music therapy.

and one-way ANOVA was used for statistical analysis. Where appropriate, Student's t test was used. A probability value of $p < 0.05$ was considered to indicate statistical significance. All data were analyzed using SAS software version 8.2.

Results

Characteristics of the subjects are summarized in **Table 1**. The mean mini-mental state examination score was 17 ± 6 which indicates a moderate level of

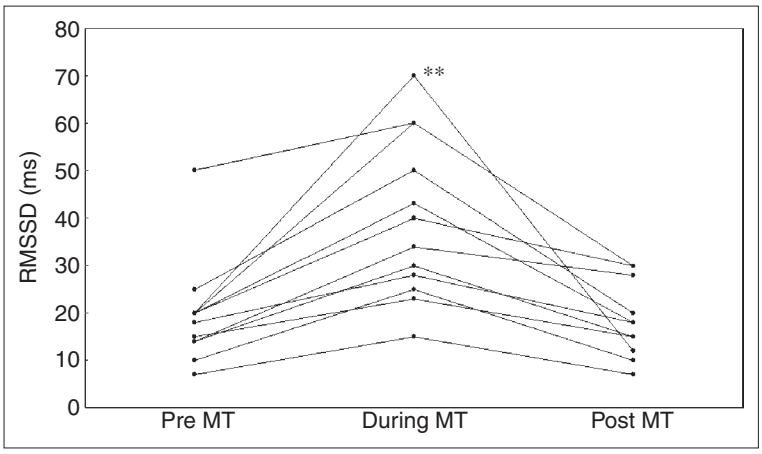

Figure 4 Changes in RMSSD.
RMSSD significantly increased during music therapy, from 19.4 ± 11 to 39.8 ± 17 ms ($p < 0.01$), and had decreased to 19.4 ± 8.4 ms at 2 hours after the end of music therapy.

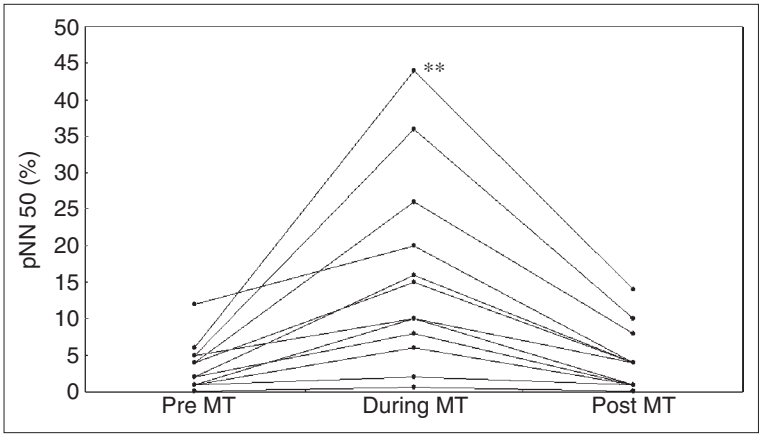

Figure 5 Changes in pNN50.
pNN50 significantly increased during music therapy, from 3.6 ± 3.2 to $16.1 \pm 13.3\%$ ($p < 0.01$), and had decreased to $4.3 \pm 4.2\%$ at 2 hours after the end of music therapy.

Figure 6 Plain brain CT of 89-year-old woman revealed large low-density cerebral infarction area in the right lateral lobe.
She was fed via a stomach tube in a condition close to complete disuse syndrome. All her ADL were performed by care workers and nurses. Despite these conditions, her HRV indices were changed markedly during music therapy. Details are explained in the text.

dementia. All subjects required help to perform certain daily activities, including eating, toileting, showering and movement by wheelchair. Seven subjects were fed via a nasal or pericutaneous endgastric tube. Seven patients had either right or left hemiplegia; and 5 patients had complete disuse syndrome. On brain CT scans, 8 patients had a typical low-density area, and 4 patients had a lacunar infarction. All laboratory parameters were within normal ranges including blood pressure and serum lipid levels (**Table 1**).

The mean RR increased significantly during music therapy, from 842 ± 174 to 1022 ± 284 ms ($p < 0.05$), and decreased to 820 ± 284 after music therapy (**Figure 1**). HF increased significantly during music therapy, from 59 ± 41 to 127 ± 97 ms^2 ($p < 0.01$), and decreased to 77 ± 60 ms^2 after music therapy (**Figure 2**). In contrast, LF/HF decreased from 2.2 ± 1.3 to 1.7 ± 1.3 during music therapy ($p < 0.10$), and increased to 2.0 ± 1.1 after music therapy (**Figure 3**). Values of all time domain HRV indices increased during music therapy and decreased after music therapy: RMSSD increased from 19.4 ± 11 to 39.8 ± 17, and then decreased to 19.4 ± 8.3 ms (**Figure 4**); pNN50 increased from 3.6 ± 3.2 to $16.1 \pm 13.3\%$ ($p < 0.01$), and then decreased to 4.3 ± 4.2 (**Figure 5**).

A typical example is shown in **Figure 6**. Despite a large low-density area in the right cerebral hemisphere and nearly complete disuse syndrome, the subject's mean RR increased from 770 to 800 ms during music therapy, and decreased to 750 ms after music therapy; pNN50 increased from 5 to 10%, and then decreased to 4 ms; and HF increased from 80 to 200 ms^2, and then decreased to 60 ms^2; in contrast, LF/HF decreased from 2.2 to 1.3, and then increased to 2.3. At the end of music therapy, tears were streaming from the subject's eyes.

Discussion

In the present study, the main effects of music therapy were to increase parasympathetic tone and reduce sympathetic tone. Music therapy is currently used to promote physiologic and psychological well being, most commonly for emotionally stressed patients in coronary care units.[2–7] Studies of effects of music on HRV using an ambulatory ECG monitoring system have been limited to healthy adolescents.[8]

In the present study, we measured autonomic nerve function by performing ambulatory ECG monitoring that automatically measured HRV, because HRV is one of the most useful indicators of autonomic activity.[9] The most widely used method of measuring autonomic activity is to measure the instantaneous heart rate and RR intervals with ambulatory ECG monitoring. The relationships between parasympathetic activity and both HF and time domain analysis from long-term heart rate recording are well established. Although there is controversy regarding the relationships between sympathetic activity and LF data due to effects of physical processes such as respiration,[9,13] we previously confirmed that the autonomic functions can be estimated from HRV parameters, even under hyperbaric conditions.[14] In the present study, each recording period was at least 180 minutes. According to the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology,[9] a recording period of approximately 1 minute is needed to assess the HF components of HRV, whereas a recording period of approximately 2 minutes is needed to assess the LF component. The time domain parameters SDNN and RMSSD can be used with relatively short recording periods. Thus, in the present study, the recording period used to obtain the series data for the sequential power spectra and time domain analysis was sufficient to confirm the physiological steady state.[9,15] The present increases in parasympathetic parameters such as HF, RMSSD and pNN50 and the decrease in the sympathetic parameter LF/HF indicate that the music therapy significantly affected parasympathetic nerve activity, despite the severity of the cerebral vascular diseases and dementia.

Several studies of music therapy have shown effects on the cardiovascular system, respiratory system, gastrointestinal system, pain, anxiety and even cortisol levels.[2–6,16,17] Lai reported that relaxing music decreased heart rate and respiratory rate and significantly increased temperature in elderly people, probably due to psychophysiologic effects in which the rhythm and tempo of the music induced relaxation and distraction responses in the limbic and hypothalamic systems of the brain.[18] The limbic and hypothalamic systems can reduce activity of the neuroendocrine system and sympathetic nervous system.[19] Reduced neuroendocrine activity may reduce corticotropin levels and the stress response by increasing parasympathetic activity and decreasing sympathetic activity.[20] It has been reported that music has 2 different primary functions for listeners. Study subjects either listen to the music and become attuned to its melodies and harmonies, or they let the music flow through their minds and project their own frozen emotions and unconscious images onto the music.[21] The auditory stimulation of music can

affect the limbic system, emotional centers and sensory signals, by reducing the ability of neurotransmitters to relay uncomfortable sensations. Reports indicate that such soothing psychophysiologic responses are induced by calm classical music, but not by rock music.[22] Areas of the hypothalamus connected to the sympathetic and parasympathetic nervous systems respond to music, even in elderly patients with cerebral infarction and dementia.

The present study has 3 main limitations. First, the sample size may not be sufficiently large, and there were no control groups. The second limitation is the possible effects of the sedatives, analgesics and vasoactive medications that were administered to the subjects. This pre-existing medication could not be discontinued during the study, for obvious medical reasons, and also because discontinuation of the medication could have had psychological effects. However, we do not believe that the medication significantly affected the present results, because none of the patients were receiving beta blockers. The third limitation is that the study subjects suffered from a wide variety of types of CVD and other diseases, which may have affected the results. Despite these limitations, the present findings suggest that music therapy is useful for alleviating anxiety, increasing comfort and facilitating relaxation for patients with CVD and dementia.

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