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Music Therapy and Heart Rate Variability in Chinese Patients with Depression

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Key words

Add-on therapy; affective disorder; depression; heart rate variability; music therapy

Abstract

Aim: Depression and cardiovascular diseases are interrelated. Music therapy is often used as add-on-therapy for patients with depression, as well as in long-term cardiac rehabilitation. While research profoundly elucidates heart rate variability (HRV) in psychiatric and cardiovascular conditions, studies on the triad depression-HRV-music therapy are still lacking, hence the present short communication. **Subjects and Methods:** From January 2022 until January 2023 the Shanghai 10th People's Hospital affiliated to Tongji University conducted an outpatient randomised controlled trial (G1 music therapy, n = 29; G2 music therapy and medication, n = 29) including patients (age 14 to 70) diagnosed with depression according to the CCMD-3 diagnostic manual, and treatment-duration 8 weeks. Affective and cardiological states were assessed through SCL-90 and 5-min-HRV before and after the entire intervenetion, which used multi-modal music therapeutic techniques, previously developed at the 10th People's Hospital. **Results:** Both groups showed marked improvement after the entire treatment. Standard deviation of NN intervals (SDNN) increased significantly in both G1 and G2 ($p < 0.05$); root mean square of successive RR interval differences (RMSSD) increased in G1 considerably, in G2 significantly ($p < 0.05$); SD1 and SD2 (Pointcaré plot) increased significantly ($p < 0.05$) in both G1 and G2. SCL-90 (depression) indicated significant im provement: G1 2.99 ± 0.99/2.40 ± 1.26 ($p < 0.05$) and G2 3.16 ± 0.94/2.60 ± 1.33 ($p < 0.05$). **Conclusion:** Both music therapy alone and combined with medication improves considerably HRV-parameters and psychopathological states in patients with depression. Combined therapy did not yield better results, which calls for clarification. As multimodal music therapy seems to be more efficient than, e.g., only listening to music, differentiation of music therapeutic styles is necessary.

Introduction

The heart is not a biological metronome. Moreover, micro-deviations of the heartbeat embody 'hidden information' which is the essence of heart rate variability (HRV) [1]. Two historical cornerstones inspired the evolution of HRV: in the early 18th century Hales observed a respiratory pattern in the blood pressure and pulse of a horse, and in 1947 Ludwig reported a dog's regular quickening of pulse rate with inspiration and a slowing with exhalation, which is today regarded as the first document about respiratory sinus arrhythmia (RSA). The second half of the 20th century gave rise to important HRV-related clinical applications, and today HRV is a

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standard in cardiology, psychosomatics and psychiatry, music therapeutic approaches included. In 1996 the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology issued HRV standards that greatly facilitate comparability and coordinated research. From an interdisciplinary perspective, HRV is linked with chaos ontology, stochastic mathematical systems and medical complexity sciences, translational medicine included.

Defining heart rate as a measure mirroring the length between two R-peaks of the QRS-complex, heart beat variability can be understood as the variation of such intervals over a given time. Notwithstanding the adequacy of this tentative interpretation, HRV is rather an umbrella term covering a variety of parameters [2]. While the interbeat interval (IBI) standard deviation of all sinus beats (SDRR) equals the heuristic conception above, HRV-studies usually refer to the 'purified' version, processing the IBI of normal sinus beats (SDNN) – 'normal' indicating that abnormal beats such as ectopic ones have been removed:

$$\text{SDNN} = \sqrt{\frac{1}{N-1}\sum_{n=1}^{N}(RR_n - \overline{RR})^2}\ ,\ \overline{RR}\ \text{indicating}\ \frac{1}{N}\sum_{n=1}^{N} RR_n.$$

The denominator N-1 relates to Bessel's correction in statistics. Moreover, HRV - reference tables often refer to the root mean square of successive differences (RMSSD) between normal heart beats:

$$\text{RMSSD} = \sqrt{\frac{1}{N-1}\sum_{n=1}^{N-1}(RR_{n+1} - RR_n)^2}\ .$$

Additionally to single parameters, graphical entropy-related distributions such as the Pointcaré plot, named after the French mathematician and philosopher of science Jules Henri Poincaré, greatly help to interpret and compare HRV-data [3]. This 2-dimensional point-cloud is generated by x = RRn / y = RRn+1 and creates an ellipse with elucidative parameters such as SD1 and SD2 for advanced HRV - processing. Dealing with HRV also involves more complex algorithms such as the HRV triangular index (HRVi), a geometrical approximation using the integral of the RR interval histogram density function alongside the triangular interpolation of the NN interval histogram (TINN) which is akin to the HRV-Baevsky's stress index SI:

$$\text{SI} = \frac{AMo \times 100\%}{2Mo \times MxDMn}$$

where AMo is the mode amplitude presented in percent, Mo (mode) indicating the most frequent RR interval. MxDMn is the scope of RR interval variability [4].

HRVi = A/h with A being the discrete integral (heuristically 'volume') over all columns – each column's height indicating the number of RR-intervals within the same lengths-interval, h being its mode's, i.e. the most frequent RR interval's height – which generate the entire histogram:

$$\text{A} = \int_{i=1}^{N} f(RR_i)$$

being the total number of RR-intervals within length RRi. Table 1 explains the parameters included in the Shanghai research, Table 2 shows the numerical data.

In sum, HRV-research is based on interdisciplinary approaches, while theories and interpretation are still in an interactive flow, hence the impossibility to absolutely elucidate the significance of data – we are rather faced with a most challenging area of medical epistemology, which also qualifies the present short communication. There is an inner link between emotion and the heart, and a wealth of studies highlight the significant statistical connection between depression and cardiovascular diseases [5]. Meta-analyses demonstrate that HRV in patients with major depression is significant lower than in healthy controls alongside related cardiovascular risk factors [6]. Complex pathological dynamics, e.g. including depression, chronic stress, anxiety and sleep issues, are equally associated with adverse HRV-parameters, while

Table 1. Heart Rute Variability - parameters

SD1	Poincaré plot standard deviation perpendicular to the line of identity
SD2	Poincaré plot standard deviation along the line of identity
power HF	Absolute power of the high-frequency band (0.15 - 0.4 Hz)
power LF	Absolute power of the low-frequency band (0.04 - 0.15 Hz)
Stress index	Square root of Baevsky's stress index SI
SD2/SD1	Ratio of SD1 to SD2
SDNN (ms)	Standard deviation of NN intervals
PNN50 (%)	Percentage of successive RR intervals that differ by more than 50ms
PNN20 (%)	Percentage of successive RR intervals that differ by more than 20ms
RMSSD (ms)	Root mean square of successive differences between normal heartbeats.
LF/HF ratio	Ratio of LF to HF power
Respiratory rate	Respiratory rate per minute

clarification of underlying mechanisms calls for interdisciplinary research [7,8]. Given that HRV is age-sensitive, developmental research on depression and HRV across the life span is vital and concerns children, adolescents and adults, as well as the older generation [9,10].

There are good reasons why poetry is brimming with the topos of music and the heart, and while subjective experience is willing to agree, scientific research uses objective approaches to confirm [11]. Music of various genres and types has been postulated to possess features that stimulate or inhibit the autonomic nervous system, which leads to variable effects on cardiovascular functions, and neuroscientific approaches revealed connections between neurocardiac and neuropsychical systems [12,13].

The dynamic interplay between music and heart rhythms alongside relatively easy HRV-techniques encouraged a broad spectrum of medical studies in this area: HRV was used to study music for stress and anxiety reduction in coronary heart disease patients, to evaluate music therapy in neonatal intensive care units (NICUs), to assess music as a means to reduce symptom clusters in oncology as well as to modulate chronic pain [14-17]. There are even studies very close to the present one, e.g. investigating the impact of music therapy on cardiac au-

Table 2. Differences in Heart Rute Variability Changes of Patients under Two Treatment Conditions (M ± SD)

	Music Therapy Group(n = 29)		Pharmacological Music Therapy Group (n = 29)	
Variable	Before Treatment	After Treatment	Before Treatment	After Treatment
SD1	24.94 ± 14.20	29.47 ± 18.47[a]	24.27 ± 12.54	30.99 ± 19.62[a]
SD2	57.98 ± 33.18	83.59 ± 38.29[a]	63.32 ± 27.05	86.03 ± 38.53[a]
power HF	874.06 ± 1436.37	1133.61 ± 1907.73	582.65 ± 608.17	887.48 ± 1331.95
power LF	1267.46 ± 2509.92	3425.50 ± 4640.96[a]	899.63 ± 1838.28	3156.29 ± 4050.12[a]
Stress index	276.38 ± 253.70	166.87 ± 163.36[a]	197.61 ± 160.32	140.32 ± 145.71[a]
SD2/SD (σ)	-0.78 ± 0.94	0.01 ± 0.99[a]	-0.15 ± 1.16	-0.10 ± 1.03[a]
SDNN (ms)	50.10 ± 43.55	64.20 ± 32.34[a]	48.47 ± 19.82	65.19 ± 29.40[a]
PNN50 (%)	15.01 ± 16.16	14.64 ± 14.93	17.39 ± 17.37	21.23 ± 19.38
PNN20 (%)	48.46 ± 24.11	45.92 ± 20.45	51.43 ± 24.95	54.72 ± 21.83
RMSSD (ms)	45.23 ± 61.79	46.52 ± 42.28	34.33 ± 17.73	43.83 ± 27.75[a]
LF/HF ratio	1.76 ± 2.20	8.78 ± 9.36[a]	3.32 ± 7.19	7.12 ± 6.46
Respiratory rate	16.28 ± 3.25	11.31 ± 4.04[a]	15.30 ± 3.71	10.58 ± 4.37[a]

Note: 'a' indicates $p < 0.05$ compared to before treatment. All abbreviations are explained in Table 1.

tonomic modulation and depression in mothers of preterms [18].

The present study wants to contribute to this therapeutic domain and particularly encourage (i) systematic and coordinated research, (ii) comparison of different music therapeutic techniques and their effects, (iii) culturally sensitive and cross-cultural studies and (iv) meta - theoretical as well as meta-synthetic considerations. Given that HRV-research is actually in a flow, it also wants to yield data for further processing or as a contribution to advanced theoretical frameworks.

Methods

Intervention method

Music therapy comprises a wealth of different methods and models that are, broadly speaking, based on cultural traditions, schools of thought or medical/scientific findings [19]. Clinical observation, heuristic thought, deductions from evidence-based music therapeutic findings and informal action research with iterative optimisation of treatment modes resulted in a complex intervention pool including eight areas for individualised application in group music therapy: (i) respect of individual aesthetic preferences and music with biographical significance, (ii) music-guided progressive muscle relaxation, (iii) synchronisation of music and movement, including sensory stimulation, symbolic self-expression and dance therapeutic elements to alleviate depression, (iv) music as a gateway to unconscious material, e.g. through guided music imagery, (v) aesthetic experience and awareness of cultural/biographical identity through song singing, starting with a Chinese folk song (e.g. Jasmine Flower, in Chinese 茉莉花Mòlihuā) followed by a patient's choice, (vi) music meditation to quarantine negative emotions and traumatic contents, as well as to experience sound as an oasis of safety and hope, (vii) creative music activities such as improvisation, collage and group compositions to enhance self-actualisation, empowerment, symbolic self-expression, and to break through petrified cognitive patterns, (viii) creative music interaction, including imitation and non-verbal dialogue [20,21].

Inclusion and exclusion criteria

From January 2022 until January 2023 the hospital's music therapy outpatient clinic enrolled patients with complex mental health conditions and selected 58 individuals for the present study. The deliberately low-threshold inclusion criteria comprised an outpatient status of the Shanghai 10th People's Hospital's music therapeutic ward, a psycho-affective CCMD-3-diagnosis (depression), and age between 14 and 70 years. Exclusion criteria applied to individuals with auditory impairment, coronary artery disease, heart failure, arterial hypertension, cardiac arrhythmia, kidney disease, hypoglycaemia, and further conditions which could negatively interact with music therapeutic dynamics such as epileptic seizures or psychotic fits.

Randomisation

This study was designed as a randomised controlled trial, enrolling 58 patients diagnosed with depression according to the Chinese Classification and Diagnostic Criteria of Mental Disorders (CCMD - 3, 3rd edition). The participants were divided into two groups: the music therapy group (G1, n = 29) and the combined music therapy and medication (SSRI/Sertraline) group (G2, n = 29). Participants underwent psychological assessments and 5-minute resting Heart Rate Variability (HRV) recording with standard parameters (Table 1) two days before the start of music therapy and after eight weeks of intervention.

Results

The Chinese Version of the Symptom Checklist-90 (SCL-90) indicated improvement in all parameters, depression included: G1 2.99 ± 0.99 before / 2.40 ± 1.26 after ($p < 0.05$), G2 3.16 ± 0.94 before / 2.60 ± 1.33 after ($p < 0.05$). The distinct numerical HRV-outcomes are shown in Table 2.

Discussion

The Shanghai music therapy model markedly improves (increases) heart rate variability in patients with depression. In contrast with studies advocating combined treatment, no considerable difference between the groups – i.e. only music therapy versus music therapy plus medication – was found. Although this study was not meant to assess antidepressive medication versus placebo, results call for further research on this over many years controversially discussed topic [22]. Comparing SCL-90 and HRV outcomes, the study brings afresh the idea of HRV as promising candidate for a diagnostic or predictive bio-marker for depression into play, alongside the crucial question of underlying mechanisms [23]. This also involves considerations whether music therapy primarily impacts on depression and via this path influences HRV-changes, or we are faced with a dual influence alongside dynamic mind-heart-interactions.

Regarding cultural sensitivity of music therapy, we finally encourage cross-cultural research alongside complex evidence studies to suggest music therapy as a standard in clinical treatment of depression.

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Conflict of Interest

None to declare.

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