Original Research

METABOLIC DISEASES

The effects of active and relaxing music on the short-term memory, attention and metabolic parameters of type 2 diabetes patients (T2DM)

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Abstract

Objective. Metabolic parameters and cognition are known to be impaired in diabetes, while music seems to have an impact on both. We aimed to study the effects of active and relaxing music on the short-term memory, attention and metabolic parameters of type 2 diabetes patients (T2DM).

Methods. A two-day interventional, within-subject study was carried on 89 T2DM patients treated only with metformin and 67 age- and sex-matched control. The Pieron Toulouse test and Word Recognition Test were used to evaluate attention and short-term memory. The music listened to was the Allegro, respectively the Andante parts of 2 Mozart Sonatas. Cognitive tests, blood pressure and blood glucose measurements were performed before and after each 20 minutes of music intervention.

Results. Baseline attention performance was better in the control group compared to T2DM ($p<0.000$). Performance improved significantly in both groups under both types of music, however the last to the first measurement difference was higher in the control group ($p=0.04$). Female T2DM participants had better improvement under active music ($p<0.01$). Short-term memory improved during active music, but this was significant only in the control group ($p=0.041$). Both types of music were associated with significantly lower systolic blood pressure ($p=0.00$), while relaxing music significantly reduced blood glucose levels ($p=0.00$).

Conclusion. Our study highlighted the beneficial effect of music on metabolic and cognitive parameters, however, its impact depends on the type of music listened. Furthermore, cognitive scores of T2DM, especially in men, were less influenced by music than those of the control group.

Keywords: music therapy, diabetes mellitus, cognitive function, blood pressure

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Introduction

Music has a multimodal effect on our brains. Besides the usual animal and human intervention studies, new techniques, such as functional MRI and PET, made possible the complex evaluation of music-related brain activity. As it has been shown by several researchers, music engages an extensive network of brain areas beyond the auditory cortex such as the inferior parietal lobe, cingulate gyrus, dorsolateral prefrontal cortex (involved also in attention and working memory), the angular gyrus, temporal gyrus and hippocampus (the center of episodic memory) [1,2].

Among others, Sridharan and colleagues demonstrated that the dynamic network effect induced by music encompasses mainly the right hemisphere. Here, activation of the ventral frontotemporal network, associated with detecting salient events, is followed by the stimulation of the dorsal frontoparietal network, essential in maintaining attention

and updating working memory [3].

Although music-based medical interventions (MBMI) were used from ancient times (it was already mentioned in the 4000 years old Egyptian scrolls and was used by the Greeks too, as a distinct therapy in the Asklepions) the evidence-based scientific research of the clinical effects of music started only a few decades ago [4]. Accordingly, it has been well established, even in clinical settings, that music, besides its stress and pain-lowering effect has a positive impact on the biological parameters and cognitive functions too [5,6]. Recent studies of MBMI involving both healthy subjects and patients with cardiovascular or neuropsychiatric diseases have demonstrated increased engagement and performance in tasks related to memory and attention, along with the improvement of affective disorders, such as anxiety and depression [7-12].

It has also been proven that MBMI lowers blood pressure [13] and cortisol levels [14], while its blood sugar-lowering effect is still controversial [15-17].

It is well known that type 2 diabetes mellitus (T2DM) is associated with lower cognitive performances and a higher degree of dementia. As it was pointed out by Kodl and colleagues, the cognitive dysfunction in T2DM affects memory, psychomotor speed, executive function, processing speed, complex motor function, verbal fluency, and attention [18]. In addition, stress also plays an important role in the evolution of T2DM, appearing both as a causative and aggravating factor and as a consequence of the disease, developing a truly vicious circle [19]. Also, a systematic review and meta-analysis summarized the effect of music therapy in 2,747 subjects, demonstrating its stress-reducing effect with a stronger impact in clinical controlled trials [20].

A review of the literature on the impact of music intervention on the management of diabetic conditions in patients showed that music intervention plays a dual role in the management of diabetic conditions in patients. Music intervention is effective in improving patient compliance with exercise, improving lower limb circulation, and improving health parameters that increase autonomous balance in diabetic patients, but it is also effective in managing diabetic conditions by reducing blood glucose, heart rate, and stress in patients. However, longer-term studies and randomized controlled trials with robust sample sizes are recommended to reach a more valid conclusion [21].

Thus, a growing number of studies address the demand for complementary therapies in diabetes care, which adopt a psychosomatic approach. However, until recently only a few of them have applied music as a therapeutic tool [22]. The handful of studies implementing MBMI in T2DM yielded inconsistent results: glucose-lowering effect of music has been confirmed in a study published by Cioca [15], while other researchers have found no short-term or long-term effect on glucose metabolism [23].

There are still a considerable amount of questions regarding MBMI. It is not clear if there are any gender differences, what are the age-related effects, what type of music is the most beneficial, and what type and length should the intervention have. Hence, our aim was to study the effects of relaxing music and active music on metabolic parameters, short-term memory, and attention in type 2 diabetes patients compared to control, a field not yet investigated.

Methods

Study population

A two-day interventional, within-subject design study was conducted, comparing the effect of relaxing and active music on metabolic parameters, attention, and short-term memory. The study population consisted of 89 patients with type 2 diabetes and 67 age and sex-matched control subjects. Type 2 diabetes patients were recruited from Diabetes Day Care Centers in Targu Mures, Romania. The T2DM patients were only metformin treated, with stable metabolic control, who were willing to participate and signed an informed consent. Participants were informed beforehand of the study procedure. Exclusion criteria for both groups were: known severe dementia, any treatment with anxiolytics, antidepressants, or other psychotherapeutics, presence of acute illnesses, bad eyesight, or illiteracy. The Ethical Committee of the George Palade University of Medicine, Pharmacy, Science and Technology of Targu Mureș approved the study.

Study procedure

The study procedure was elaborated by a physician specializing in internal medicine and diabetes care and the investigation was performed by three pre-trained interventionists (physician and students).

The intervention was performed in a Day Care Centre for two consecutive days in a three months period. Participants arrived, having fasted for at least 8 hours, they were isolated in a room with a very low level of ambient sound, and asked to sit and rest for at least 5 minutes, after which the intervention was performed. We used the Pieron Toulouse test to evaluate attention, and the Word Recognition Test (WRT: 40 words read during music, recognized afterward from a list of 80 words) for short-term memory. Only 50 patients from each of the two groups were accepted to complete the attention test and/or to perform the short memory test. According to available evidence about the specific beneficial effect of Mozart's music [24], we chose as "active" music the *Allegro con spirito* part of the K448 Sonata for two pianos in D-major (tempo 140 beats/min) and as for the relaxing music the *Andante grazioso* part of the K331 Sonata nr. 11 in A-major for pianos (tempo 50 beats/min) of Mozart. Music tracks were preselected and volume was determined by the investigator. A wireless OPEN P47 Stereo headphone was

used for music listening. Blood pressure measurements were done using a calibrated Omron M2 Basic monitor. Blood sugar was measured from capillary blood using a One Touch Select glucometer.

On the first day, after measuring blood pressure and glucose level, the Pieron Toulouse test was performed, followed by 20 minutes listening of to the Allegro part of the K448 sonata for two pianos by W.A. Mozart on headphones. Subsequently, blood pressure and glucose measurements were performed and patients completed again the Pieron Toulouse test. After a 30-minute intervention-free interval (during which participants stayed in the room) the above procedure was repeated, but this time listening 20 minutes of the Andante part of the K331 sonata of Mozart.

On day 2, under similar conditions as above, participants underwent the Word Recognition Test (40 words read for 5 minutes on a screen with background music, recognized afterward from a list of 80 words). First blood pressure and blood sugar measurements were done, and the word recognition test was performed while listening for 5 minutes to the Allegro part of the K448 sonata for two pianos of Mozart, simultaneously with 40 words appearing on screen. This was followed by blood pressure and glucose measurement and the task to recognize those 40 words from an 80 words list. After the 30-minute intervention-free interval the above procedure was repeated with 5 minutes listening to the Andante part of the K331 sonata of Mozart, followed by measurements and word recognition.

Assessment of attention performance by Toulouse Pieron test (%) was done by the formula: Score = (s -m) x 100/n, where s = nr. of elements evaluated, m = nr. of mistakes and n = total nr. of elements. To assess short-term memory, the percentage of correctly recognized words was calculated.

Statistical analysis

The SPSS Statistical software (version 17.0) was used for data analysis. We used a linear regression test to see the impact of age on test performance. Data between the two groups were compared with a parametric independent sample t-test and nonparametric Wilcoxon test for smaller groups (for example T2DM women) because of the relatively low number of participants. Parameters before and after the intervention were compared using paired tests. Results were considered significant if $p < 0.05$.

Results

Gender distribution: 41.6% of the T2DM group and 37.3% of the control group were male; mean age was 63.82± 9.716 and 62.06 ± 10.96 years respectively (minimum age 30, maximum 87 years). There was a significant difference in the baseline attention performance in favor of the control group (39.48±13.96 vs 50.45±15.89, $p<0.000$). In both groups, age negatively correlated with the initial test performances (B =-.693, $p<0.000$), but did not influence the before-after differences. There were no gender differences in none of the parameters neither at baseline nor after the intervention, except in the T2DM group where women had a better attention improvement after the active music intervention (attention performance difference was 9.94± 8.2 in women vs. 3.7± 7.6 in men, $p<0.01$). The differences between the two studied groups are shown in table I.

Attention performance was constantly improving during both interventions, with the repetition of the Pieron Toulouse Test in both groups (Figure 1), probably by the learning process. However, the last to the first measurement difference was higher in the control group (15.56 ± 9.87 in the T2DM group vs. 20.35 ± 13.04. in the control group, $p=0.041$) (Figure 2).

Active music has higher (but not statistically significant) impact on attention performance in relation to baseline attention score. The figure contains data of both intervention groups.

Table I. Difference of parameters in the two groups.

	Type 2 diabetes (89)	Control (67)	Sig.(2-tailed)
Age (years)	63.82 ± **9.71**6	62.06 ± 10.96	Ns
Sex (%, men)	41.6 (37)	37.3 (25)	Ns
Baseline attention performance (%)	39.48±13.96	50.45±15.89	**.00**
Attention performance difference after relaxing music (%)	7.44±8.51	8.32 ± 12.64	Ns
Attention performance difference after active music (%)	12.27 ± 6.75	10.68 ± 10.81	Ns
Attention performance difference from the last to the first measurement	15.56± 9.87	20.35± 13.04	**.04**
Word recognition at baseline (%)	59.3 ±13.6	58.14±16.8	Ns.
Word recognition with active music (%)	58.4 ±21.4	63.00± 17.4	Ns
Word recognition with relaxing music (%)	56.02± 20.0	58.05± 20.7	Ns
BP difference with active music (mmHg)	-4.7 ±11.34	- 6.61 ±11.9	Ns
BP difference with relaxing music (mmHg)	-9.06 ± 3.63	- 3.44 ±4.3	**.01**
Glycaemia difference with active music (mg/dl)	.132 ± 9.81	.278 ± 6.75	Ns
Glycaemia difference with relaxing music (mg/dl)	-4.3 ± 7.3	-2.5 ± 7.5	Ns

BP – systolic blood pressure.

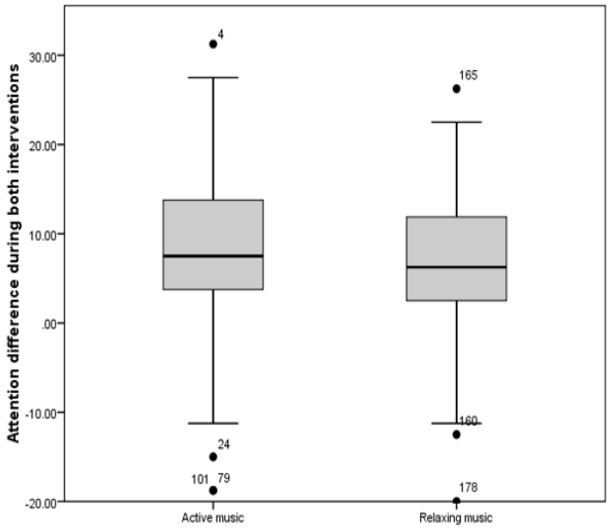

Figure 1. Attention score improvement according to the type of music.

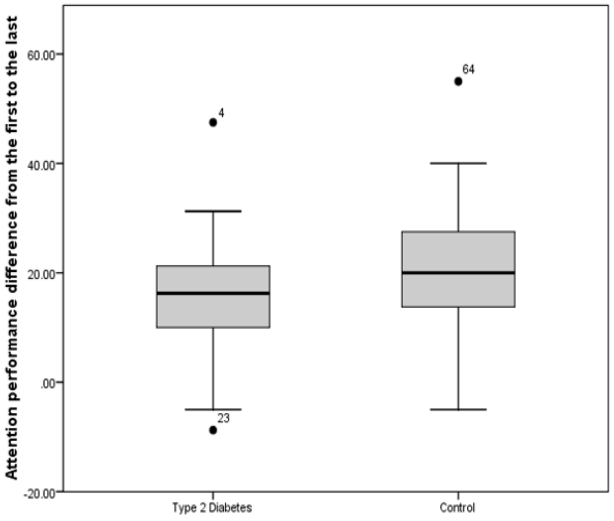

Figure 2. Attention performance improvement from the first to the last measurement.

Better attention performance improvement from the first to the last measurement in control group. The figure contains data of both music interventions.

The improvement of metabolic and cognitive parameters in all participants during the intervention with active and relaxing music are shown in table II.

In all the participants active and relaxing music had a highly beneficial effect on systolic blood pressure, but only relaxing music lowered diastolic blood pressure (however, not significantly) and glycemia. There was no difference in the outcomes regarding the effects of active and relaxing music on attention. Short-term memory was better with active music; however, this difference was significant only in the control group.

Table II. Paired samples of the effects of active and relaxing music on metabolic and cognitive parameters in all participants.

	Mean	95% Confidence Interval of the Difference Lower-Upper		T value	Sig. (2-tailed)
SysBP1 A - SysBP2 A	5.53	3.68	7.37	5.47	**0.00****
DiaBP1 A - DiaBP2 A	.532	-.66	1.72	.94	0.34
SysBP1 R - SysBP2 R	6.25	4.22	8.27	5.49	**0.00****
DiaBP1 R - DiaBP2 R	1.32	.05	2.58	1.69	0.09
G1 A - G2 A	.20	-2.03	2.43	.88	0.37
G1 R - G2 R	3.42	1.90	4.93	4.44	**0.00****
Att.test1 A - Att.test2 A	-7.88	-10.01	-5.75	6.43	**0.00****
Att.test1 R - Att.test2 R	-6.17	-7.88	-4.46	6.16	**0.00****
DsysBPA - DsysBPR	.44	-2.69	3.57	.03	0.97
DdiaBPA - DdiaBPR	.11	-1.80	2.02	.38	0.69
DGA - DGR	2.83	-.37	6.03	1.36	0.17
DAtt.testA - DAtt.testR	1.70	-1.11	4.52	.54	0.58
WRT A - WRT R	3.33	.17	6.50	1.89	**0.05***

SysBP = systolic blood pressure, DiaBP = diastolic blood pressure, G = glycaemia, Att.test = attention test score, WRT = word recognition test for short memory, A = Active music, R = Relaxing music, 1= before music intervention, 2 = after music intervention, D = before and after music intervention difference

** = highly significant, * = marginally significant

Discussion

In our study, listening to both active and relaxing music caused a significant improvement in systolic blood pressure. This effect is comparable to other findings. A meta-analysis performed by Loomba and colleagues including 11 studies with a total number of 654 patients also showed a beneficial, blood pressure-lowering effect of music [25]. The response of cardiovascular, respiratory, and autonomic systems to music seems to be strictly related to music characteristics, especially tempo and rhythm structure. While slow or meditative music has a relaxing effect, a faster tempo induces an increase in ventilation, blood pressure and heart rate, compared to baseline. However, implementing a pause followed by music with a faster tempo can reduce above mentioned parameters even below the baseline [26]. Relaxing and active music had no statistically significant impact on diastolic blood pressure in our population.

In the present study, active music did not influence blood sugar levels, but relaxing music decreased it both in T2DM and the control group, the obtained difference between the two different types of music was significant. Several studies have pointed out that music contributes to lower blood glucose levels, however majority of these were carried out in surgical or postoperative settings, which represent highly stressful situations [27,28].

A systematic review by Finn and collaborators assessing 44 studies, found a beneficial effect of music on multiple biomarkers, such as glucose, cytokines and cortisol. The majority of biomarkers tested by the processed studies were part of biological stress pathways, while nearly half of them were reported to change in response to listening to music, suggesting that the primary way of music affects us is through modulation of the stress response [29]. Music is probably improving blood pressure and glycemia through stress control mechanisms, and this could explain the more beneficial effect of relaxing music, as it was suggested in our results.

Our study is one of the first to compare the short-term effects of two different kinds of music on cognitive parameters in patients with T2DM. As expected, attention performance and short-term memory correlated with age in both study groups, but the overall difference obtained by the intervention was not influenced by the age of the patients, showing that the beneficial effects of music may be present at any age.

Attention performance was significantly higher in the control group compared to T2DM at baseline, showing an attention deficit in T2DM patients. This is in concordance with the literature showing the association of diabetes with decreased cognitive performance [30]. However, considering baseline WRT for short-term memory, the difference between the two groups was not significant.

It was demonstrated that besides its beneficial impact on stress, music interventions might also improve memory and attention both in normal aging and in diseases showing cognitive declines, like Alzheimer's dementia [31], Parkinson's disease [32] or stroke [33]. Although lasting effects are achieved through regular and long-term therapeutic interventions, there is emerging evidence that short-term interventions could also lead to temporary improvement of cognitive performance in attention or memory, presumably because of their enhancing effect on mood and arousal. However, findings related to attention and short-term memory performance under music intervention are controversial [34,35].

In our study, attention performance was improved after each intervention; however, it is not clear whether this was due to the music intervention or the learning process. There were no differences regarding the attention improvements between the two groups (T2DM and control). The difference obtained by listening to active versus relaxing music was not significant. The degree of improvement (from the first to the last testing) was significantly higher in the control group, showing a better learning and attention improvement ability of the control group compared to patients with diabetes.

Women in the T2DM group had a higher improvement of attention performance with active music than T2DM men. There is some evidence in the literature that women are more sensitive to psychosomatic interventions like psychotherapy and music intervention [36].

Short-term memory performance was identical in the two groups at baseline. Active music improved this performance versus baseline and versus relaxing music in the control group, but not in the T2DM group. It seems that there is a lower capability to improve short-term memory in patients with diabetes. A possible cause of these inconsistent results could be the heterogeneity in the type and length of music listening interventions, and in the type of test assessing cognitive functions, respectively [37-39].

Limitations of this study include small population size, lack of measurement of these parameters after longer periods of music intervention, and multiple sessions.

Conclusion

Both types of music interventions achieved an improvement in systolic blood pressure, but only relaxing music had an effect on glycemia, this effect being more substantial in the T2DM group. There was an overall improvement in attention with both types of music, the effect being greater in women. Short-term memory was improved with active music, but not in the T2DM group.

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