

## Effectiveness of Music Therapy on Focused Attention, Working Memory and Stress in Type 2 Diabetes: An Exploratory Study

### Abstract

Cognitive deficits are reported in diabetes mellitus type 2 (DM2). Previous research has shown that music-based intervention can not only reduce hyperglycemia but also target cognitive functions as well as stress. The aim of this exploratory study was to understand the effect of active participation in music therapy (MT) on the cognitive deficits of DM2 patients. MT of twenty sessions was carried out with three participants with DM2. Serum cortisol, perceived stress, Color Trail Test (1 and 2), and verbal n-back (1 and 2) tests were used to measure the outcomes. Feedback was taken for the subjective ratings and satisfaction of the participants. Stress and cortisol reduced and focused attention and working memory improved in varying degrees. Subjectively, participants reported having benefitted from the intervention. This is the first attempt to investigate the effect of music-based intervention on cognitive function in DM2 patients using case study approach.

**Keywords:** *Cortisol, focused attention, music therapy, perceived stress, working memory*

### Introduction

Type 2 diabetes (T2D) is a complex metabolic disorder leading to cognitive deficits and increased risk for multiple clinical conditions such as dementia and stroke and several other micro- and macro-vascular diseases.<sup>[1]</sup> High levels of psychological stress are also considered as one of the causal and maintaining factors of this condition.<sup>[2]</sup> There is growing evidence of the effectiveness of music not only to improve cognitive functions in conditions such as traumatic brain injuries,<sup>[3]</sup> stroke,<sup>[4]</sup> and dementia<sup>[5]</sup> but also in the reduction of stress,<sup>[6,7]</sup> anxiety,<sup>[8]</sup> and cortisol production,<sup>[9]</sup> and increase in dopamine levels.<sup>[10]</sup> With lifelong dependency on medication and likely physical side effects, there is a need to explore intervention methods that can facilitate not only reduction of stress but also target cognitive dysfunction in T2D. Research on the effects of music therapy (MT) on stress has been reported. MT has reduced stress in the students caused by a stressor<sup>[7]</sup> and anxiety and stress of T2D patients.<sup>[8]</sup> It is in the recent times with evidence from neuro-musicology and music cognition that active as well as passive engagement in

music has shown to have positive effects on cognitive functions. There is no study hitherto examining the effects of MT on not only stress but also cognitive functions. The aim of the present study was to examine the effect of active participation in MT on the cognitive functioning of diabetes mellitus type 2 (DM2) patients. In the first place, we sought to understand the influence of active participation in MT on memory and focused attention, second, on cortisol and perceived stress, and finally on the subjective rating and satisfaction. It is found that active music therapy (AMT) is more beneficial than passive listening.<sup>[11]</sup> Singing improved the executive function of the children.<sup>[12]</sup> AMT is actively participating in MT by singing or chanting or reciting. The objective of this exploratory study was to examine the effect of using case series study design with pre-post evaluation.

### Methods

The present study included three participants diagnosed with DM2 confirmed with the HbA1c levels. Sociodemographic details of the participants are provided in Table 1. Written informed consent was taken from the participants after the study was approved by the Institutional Ethics Committee, Swami

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**Table 1: Details of the participants**

Cases	Gender	Socioeconomic status	Age in years	Duration of illness (T2D)	Profession	Education in years	HbA1c
1	Male	Higher middle	45	10	Business	17	8.1
2	Male	Higher middle	47	11	Business	15	10.2
3	Male	Higher middle	47	7	Business	15	13.1

HbA1c = Glycated hemoglobin, T2D = Type 2 diabetes

Vivekananda Yoga Anusandhana Samsthana, Bengaluru, Karnataka, India. MT was administered in addition to their treatment as usual, i.e., regular medication for DM2. Levels of stress were measured objectively by measuring serum cortisol, and the subjective evaluation of stress was measured using Cohen's perceived stress scale (PSS). Each item was rated on a 5-point scale ranging from never (0) to almost always (4). Positively worded items were reverse scored, and the ratings were summed, with higher scores indicating more perceived stress. PSS-10 scores were obtained by reversing the scores on the four positive items: For example, 0 = 4, 1 = 3, and 2 = 2, and then summing across all 10 items. Items 4, 5, 7, and 8 are the positively stated items. Rensis's 10-point Likert scale was used to understand the rate of satisfaction. Verbal working memory and focused attention were measured using verbal n-back 1 and 2 tasks (Rao *et al.*, 2004) and Color Trail Tests (CTT) 1 and 2 (D'Elia and Satz). In n-back 1, the participant responds to the repeated (9) consonants from thirty randomly ordered consonants common to multiple Indian languages. In n-back 2, the participant responds whenever a consonant is repeated after an intervening consonant. In CTT-1, the participant points out the randomly spread numbers from 1 to 25, odd numbers in pink circles and even numbers in yellow ones in ascending order. In CTT-2, the participant points out in ascending order the randomly arranged numbers from 1 to 25, leaving number 1, others repeated once in pink and once in yellow circles. The main measure in this test is the time necessary to complete the task. A semi-structured interview was carried out to know the participants' experience with the intervention. The interviews were video recorded. The serum tests were done by the National Accreditation Board for Testing and Calibration Laboratories-accredited laboratory, Metropolis Health Care Ltd. All measurements were administered pre- and post-intervention. Serum cortisol was measured both the times (pre and post) in between 4.30 and 5 p.m. The experiment was carried out daily (excluding Saturdays and Sundays) for 45 min. The protocol of MT is given in Table 2.

### Detailed protocol of music therapy

The devotional songs were set for each day of the week. Every week, the same devotional songs were repeated for familiarity. The participants' individual songs were not repeated. The same piece of flute music was played for all the sessions. There were total 20 sessions.

**Table 2: Daily practice**

Activity	Item	Time:min
Sitting in silence		5
Chanting	"OM" 3 times	1/2
Lead and follow singing	Devotional	4
Individual singing	Participants' choice	3
Lead and follow singing	Devotional	3
Individual singing	Participants' choice	3
Lead and follow singing	Devotional	3
Individual singing	Participants' choice	3
Lead and follow singing	"Nirvana shatakam" (devotional)	5
Listening	Recorded flute music in raga Darbari Kanada by Hariprasad Chaurasia (Hindustani) without rhythm	10
Sitting in silence		5
Closing	OM shanti, shanti, shanti	1/2

## Results

The number of sessions attended by the participants were 16, 14, and 10 by cases 1, 2, and 3, respectively. The period between the pre- and post-test is 1 month, weekly five sessions.

In all the three cases, the cortisol level reduced after the therapy. PSS showed improvement in two cases and no improvement in other case [Table 3]. Focused attention as assessed using the Color Trails Test 1 nominally improved in one case and deteriorated in two cases at postintervention. The performance improved in two cases and showed no improvement in the other case in CTT2. In verbal n-back test 1, the performance improved in two cases and did not improve in the other case. Performance on the verbal n-back 2 did not improve in any case [Refer to Table 4a and b]. All the three patients enjoyed the intervention and rated it as 9.5 satisfactory on 10-point Likert scale [Table 3]. Video interviews provided the report of the benefits of active participation of the participants in MT.

## Discussion

The present study aimed at exploring the effects of AMT on cognitive functions and perceived levels of stress. In this study, all the three participants showed significant cognitive impairments in the domains of focused attention

and verbal working memory compared to age, education, and gender-matched Indian norms<sup>[13]</sup> The 15<sup>th</sup> percentile score (1 standard deviation below the mean) was taken as the cutoff score.<sup>[14]</sup> In the critical review study of, “Is Type II Diabetes Associated with an Increased Risk of Cognitive Dysfunction?,” it was observed that patients with T2D had moderate degrees of cognitive impairment in verbal memory. It was reported that a study which evaluated 28 T2D patients aged <55 years showed poorer performance on the measures of memory and attention.<sup>[15]</sup> These deficits are due to neural slowing and increased cortical atrophy,<sup>[16]</sup> with higher levels of HbA1c in the present study. As a result, the cognitive task completion required greater time and had difficulty for the participants compared to the normative performance expected for the Indian males in this group. The participants differed in the way they responded to active music participation. Not all the three participants had consistent improvement on all cognitive tasks. The group singing in lead and follow manner may have improved the verbal working memory as group

singing enhanced the mood of patients with chronic pain<sup>[17]</sup> and improved the mental health and well-being of the participants of singing.<sup>[18]</sup> The inconsistent improvement in this study may be due to the subjective emotional state at the time of measurement, or the cognitive functions perhaps require much more focused intervention, or the intensity and duration of the present intervention was not sufficient to bring about significant changes in the cognitive functions. However, the reduction in the cortisol level shows that AMT is feasible to relieve stress as listening to music reduced cortisol production<sup>[9]</sup> and relieved stress.<sup>[6,7]</sup> The interviews also provided the following subjective positive responses to the AMT.

- The video interviews were taken after 12 sessions
- Interviews were transcribed
- The gist of the interviews are provided below.

**Case 1**

It is a very good experience. I am feeling relaxed. The sessions are enjoyable. The therapy is very useful. My singing improved. I love relaxation with flute music. I like the interactive sessions most. This therapy should be spread. I feel the difference after the therapy.

**Case 2**

I am very happy to participate. The sessions are very interesting. I like the sequence of the songs. I enjoy group singing. I feel calm after the session. It helps me to sleep. The songs are well coordinated. Nirvana Shatakam singing

**Table 3: Pre-and post-scores on the perceived stress scale, cortisol, and visual analog scale**

Case	PSS		Cortisol		LS 10
	Pre	Post	Pre	Post	
1	26	26	4.31	3.47	10
2	13	10	10.26	8.61	9
3	27	15	5.04	2.93	10

PSS = Perceived stress scale, LS = Likert scale

**Table 4: Raw scores of verbal n-back 1 and 2 tests**

N-back 1 pre				N-back 1 post				N-back 2 pre				N-back 2 post			
Hits	EO	EC	EO+EC	Hits	EO	EC	EO+EC	Hits	EO	EC	EO+EC	Hits	EO	EC	EO+EC
4	5	2	7	9	0	0	0	2	7	1	8	4	5	1	6
7	2	2	4	8	1	1	2	4	5	0	5	4	5	2	7
9	0	2	2	8	1	2	3	7	2	3	5	7	2	4	6

EO = Error of omissions, EC = Error of commissions

**Table 4a: Raw scores of Color Trails Tests**

Cases	CT1 pre		CT1 post		CT2 pre		CT2 post	
	Seconds	Percentile	Seconds	Percentile	Seconds	Percentile	Seconds	Percentile
1	35.9	100-97	53.1	71-68	76.27	97	74.5	91-88
2	52.53	68-65	73.6	44-38	130.37	41-38	94.4	97-94
3	84.59	58-35	78.8	44-38	13.03	24-18	85.6	>100

CT1 = Color Trails one, CT2 = Color Trails two

**Table 4b: Pre-and post-intervention percentile scores on the cognitive tests**

Case	Verbal n-back 1 percentiles				Verbal n-back 2 percentiles				CT1 time seconds percentiles		CT2 time seconds percentiles	
	Hits		Errors		Hits		Errors		Pre	Post	Pre	Post
	Pre	Post	Pre	Post	Pre	Post	Pre	Post				
1	<5	40-95	<3	100	<5	<5	3	3	100-97	71-68	97	91-88
2	<5	5	3	21	<5	<5	29	15	68-65	44-38	41-38	97-94
3	5	<5	6	6	<5	<5	29	18	38-35	44-38	24-18	>100

CT1 = Color Trails Test 1, CT2 = Color Trails Test 2

is the most liked part for me. It makes me deeply relaxed and calm.

### Case 3

I feel much more relaxed. Blood sugar (fasting) reduced from 400 to 270. I like the singing and interaction part.

The satisfaction of the participants and their willingness to attend AMT in future give support to the administration of MT to other DM2 patients. The subjective reports and the PSS scores show that active participation in music is a mood-elevating strategy which can enhance positive feelings. To substantiate its role in cognitive functions, there is a need for long-term follow-up of cases with more focused intervention with selected chants and musical content.

### Conclusion

- This is an exploratory study dealing with three cases
- The results are inconsistent
- In spite of poor cognitive performance, the positive subjective response and reduced PSS scores provide a support to continue MT further
- The lower level of cognitive functions may be due to higher levels of HbA1c
- A randomized controlled trial study with larger cohort will be required to establish the findings further.

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Liability release.

### Conflicts of interest

There are no conflicts of interest.

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