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Research Article

Proposal of Music Therapy Protocol for Ataxic Patients

Yuri Giffoni*, **Rita de Cassia Moura**

Department of Music, Faculdade Santa Marcelina (FASM), São Paulo, Brazil

Abstract

Neurologic music therapy has been studied as an alternative methodology to stimulate neurological patients in a motor rehabilitation process. It uses music and its elements in a feedback-feedforward system, promoting an environment for neuroplasticity and re-learning of movements. Research to evaluate the use of neurologic music therapy in patients with ataxia due to Parkinson's and Stroke diseases has shown positive impacts on function rehabilitation, resulting in improvements in activities of daily living and life quality self-perception. The main goals for patients with ataxia described in available research are related to the positive impact on gait function, limb movements, speech, and postural impairment. The most commonly used techniques in neurologic music therapy research are Therapeutical Instrumental Music Performance (TIMP) and Rhythmic Auditory Stimulation (RAS). Literature indicates that both techniques are typically studied independently. Research on the application of neurologic music therapy to ataxic patients, whether due to genetic factors or acquired cerebellar damage, as well as protocols to assist music therapists in implementing these methodologies, are not available. The objective of this study is to propose a music therapy protocol for patients with ataxia from any disease or acquired, using neurologic music therapy and its techniques (TIMP and RAS), to measure the contribution in reducing impacts of ataxia in motor functions, improving patients' autonomy in daily living activities and as a consequence higher life quality self-perception, also contributing to increasing literature availability regarding this theme. For protocol application feasibility and considering ataxia prevalence in the total population, an experimental group of 15 patients diagnosed with ataxia without impairment on auditory systems will be designed.

Keywords

Music Therapy, Neurologic Music Therapy, Ataxia

1. Introduction

Ataxia is caused by cerebellar dysfunction, impacting its motor and fine-tuning capabilities for processing input and output information with other parts of the central nervous system (CNS). This dysfunction may originate from genetic factors or acquired cerebellar damage. Movements required for oculomotor control, speech, balance, and the movements of superior and inferior limbs can be impacted by ataxia, leading to impairments in gait and balance [1]. Consequently, this reduces autonomy in performing activities of daily living (ADL) and diminishes life quality self-perception [2].

Among the existing rehabilitation therapies for ataxia patients [3], Neuro Music Therapy (NMT) has been a preferred choice for researchers once NMT is based on the neuroscientific model of music perception, production, and influence, not only on musical-related cerebral areas but also on non-musical related and behavioral cerebral areas [4].

*Corresponding author: giffoniy@gmail.com (Yuri Giffoni)

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From the musical elements, rhythm shows high impact on stimulating neurophysiological changes in neuronal connection and structures, such as sensorial-motor areas, pre-frontal cortex, basal ganglia, and cerebellum, observed in short and long terms [5].

Thaut and Hoemberg, in the book "Handbook of Neurological Music Therapy", describe that music communicates temporal sensory information to the brain, which deeply impacts development, learning, and function rehabilitation. In some NMT techniques, musical communication primarily stimulates motor functions. TIMP – Therapeutical Instrumental Music Performance describes the use of musical instruments to retrain functional movement abilities. RAS – Rhythmic Auditory Stimulation explains how rhythm and its processing stimulate the rehabilitation, development, and maintenance of intrinsic biological movements, primarily gait, which requires limb symmetry and balance [4].

TIMP and RAS techniques are described as independent techniques of NMT, recommended for all types of cerebellar ataxia. Although available studies are focused on patients with Parkinson's Disease (PD) [6] and stroke [7], they are mainly applied to improve gait [5].

Research and protocols specifically addressing the application of NMT techniques for ataxic patients were not found in the available literature. However, considering the general application of NMT techniques to neurological patients, it is reasonable to conclude that ataxic patients can also benefit from this approach.

Additionally, this research could contribute to developing a protocol for NMT and its techniques (TIMP and RAS) for ataxic patients with ataxia acquired from any etiology, as well as expand the available literature on this theme.

2. Materials and Methods

The objective of this study is to propose a music therapy protocol for ataxic patients from any etiology. Candidate selection will consider patients referred by the Neurology department of Santa Marcelina Hospital with a diagnosis of ataxia and a recommendation for a rehabilitation program. Exclusion criteria after referral by the Neurology department will include any diagnosis of impairment in the auditory system or central auditory processing, as TIMP and RAS techniques require a functional auditory system.

Sample size calculation considers previous studies [8, 9], which show the frequency of ataxia in the total population across all etiologies as less than 40 cases per 100,000 population. This allows the use of sample size calculation by proportion estimation methodology [10], with the formula and components described below:

$$Sample\ size = \frac{\left(Z_{1-\propto/2}\right)^2 (p)\,(1-p)}{d^2} \quad (1)$$

Where: $Z_{1-\propto/2}$ is the standard normal variation for a 95% confidence interval, at 5% type 1 error (P<0.05), which is 1.96;

p = the proportion of incidence shown in previous studies [8, 9], for ataxia incidence less than 0.04;

d = Absolute error, considered by this study to be 10%.

$$Sample\ Size = \frac{(1.96)^2 (0.04)\,(1-0.04)}{0.1^2} \quad (2)$$

An experimental group of 15 patients, all genders, between 30 and 70 years of age [11], will be designed. Patients will be requested to accept and sign an Informed Consent Form approved by the Ethical Committee for research at Faculdade Santa Marcelina. It is important to reinforce that the literature shows high variance in sample sizes for studies on ataxic patients. In a systematic review study of physiotherapeutic and pharmacological interventions in cerebellar ataxia [8], six studies showed sample size variation from 4 to 40 patients regarding the experimental group.

The protocol design is split into two parts. "Part I" starts with the evaluation of initial conditions and the definition of the patient baseline, continuing with movement exercises. "Part II" describes the transition from movement to gait exercises, ending with an evaluation of improvements.

In "Session 1" of "Part I," evaluations will be conducted by an independent researcher to establish parameters such as balance, gait, and ataxia rate. These evaluations will use tests available in the literature, such as the Timed Up & Go test [12], SARA – Scale for the Assessment and Rating of Ataxia [13, 14], and the Quality-of-Life evaluation WHOQOL – BREF [15]. To provide the music therapist with information on the patient's relationship with music and its elements, the Music Therapeutical Questionnaire (MTQ) will also be applied. A summarized description of each test is provided at the end of this session.

In summary, the MTQ must provide the music therapist with an understanding of the patient's sound and musical background, preferences and rejections, memories and emotions associated with these sounds and music. Based on the MTQ, music and sounds will be selected for use as musical resources during the session's exercises according to their objectives. The music therapist can also change music elements such as tempo, rhythm, and instrument timbre to better adapt or motivate the patient during movement execution [5].

Continuing "Part I" of the protocol, 50-minute sessions of music therapy interventions will be conducted, where music and its elements, especially rhythm, will be offered to the patient through instruments and songs for patient and therapist interactions. This approach combines music and movement exercises. These combinations are supported by TIMP and RAS techniques of NMT, which also propose gradually increasing movement complexities by involving combined movement with postural positions and instrument interactions.

"Part II" involves the transition from TIMP to RAS exercises to improve gait. RAS uses auditory stimulation through

musical listening and proposes gradual gait improvement by increasing distance and speed, all supported by rhythm, which serves as a reference for starting and ending movements.

Ending "Part II" of the music therapy protocol is the improvement measurement, conducted by an independent researcher, using the same tests applied in "Session 1," in a session named "Final Session." After the full protocol execution, a total of 28 sessions will have been applied.

Scores from "Session 1" and "Final Session" for the Timed Up & Go test and SARA – Scale for the Assessment and Rating of Ataxia will be statistically compared using the Chi-Square test to verify the protocol's impact on patient rehabilitation. Improvement in Quality-of-Life evaluation WHOQOL – BREF results will also be verified by simple score comparison.

This music therapy protocol is currently in the proposal phase, no patient recruitment has started, nor has the protocol been applied.

2.1. Timed up & Go 3m Test Description

The patient, sitting on a chair, is requested to stand up and walk 3 meters, turn around, return, and sit down again. For patients using walking support, like a walking stick or crutch, the device should be available during the test execution. The length and time of each walking step, as well as the total time, should be recorded during the test execution [12].

2.2. SARA – Scale for the Assessment and Rate for Ataxia

This scale provides a system to evaluate and rate clinical symptoms of ataxia, including gait, stance, sitting, speech disturbance, finger chase, nose-finger test, fast alternating hand movements, and heel-shin slide [13, 14]. The principal researcher should apply the SARA test and send the video recordings to an external, qualified researcher for final rating.

2.3. WHOQOL – BREF

This questionnaire, developed by the World Health Organization Quality of Life Group (WHOQOL Group), is a reduced version of the WHOQOL-100, consisting of 26 questions divided into four domains: physical, psychological, social relationships, and environment. It provides a score of the patient's self-perception regarding Quality of Life [15].

3. Results

The protocol is designed in two parts to focus on specific neurological music therapy techniques and progressive objectives. Figure 1 shows "Part I" of the protocol, which includes "Session 1" and tests to define the patient's baseline, followed by music therapy interventions aimed at vestibular and motor rehabilitation. These interventions involve increasing postural complexity and movements of the trunk, ocular-encephalic parts, and both upper and lower limbs. This part of the protocol uses TIMP as the NMT technique and spans 7 weeks, with 2 sessions per week, totaling 14 music therapy sessions.

"Part II" of the protocol, shown in Figure 2, designs sessions to transition from TIMP to RAS techniques, with a focus on balance and gait as the main goals. It concludes with the "Final Session", where tests from "Session 1" are reapplied to assess the protocol's benefits on patient rehabilitation. "Part II" also spans 7 weeks, with 2 sessions per week, totaling 14 music therapy sessions.

Based on the MTQ, music and its elements will be selected and adjusted according to the patient's conditions.

The protocol describes the session schedule, the NMT technique to be applied in each session, patient positioning, and musical elements such as music tempo and bar [16]. It also considers the patient's condition, the targeted movements, and the musical resources to be used in each session [4, 17-19].

4. Discussion

The presented protocol is designed for patients with ataxia, targeting movements related to motor rehabilitation for those with cerebellar dysfunction and its associated connections. Considering that the cerebellum continuously fine-tunes the vestibular system [20], initial sessions will assess cerebellar demands through vestibular system movements based on Cawthorne-Cooksey exercises [21]. This involves a sequence of oculo-encephalic movements and postural position enhancements, starting from lying down, progressing to sitting, transitioning to standing, and ending in a standing position. This gradual increase in demand on the cerebellum and vestibular system aims to reduce the impact of postural impairment, which is crucial for balance and gait required to the next sessions.

This is also a music therapy protocol that applies NMT concepts and techniques, using music and musical elements to stimulate retraining of impacted movements.

Based on the MTQ, the music therapist can select musical activities that best adapt to the patient's initial condition. By adjusting elements such as rhythm, tempo, and bar, the therapist can determine increases in movement speed and complexity, which are important for rehabilitation progress and the patient's self-confidence.

The bar is also an important variable for increasing stimulation and exercise complexity, as it allows the music therapist to transition from quaternary musical activities/listening, where movement is divided into 4 steps (right-center-left-center), to binary activities, divided into 2 steps (right-left directly). This transition increases speed and places greater demands on the vestibular system.

The protocol also provides musical resources for each session, exemplifying the types of instruments or adjustments required to apply NMT techniques, TIMP, and RAS.

Week	Session	NMT Technique	Patient Position	Tempo (BPM) Beats per minute	Bar Form	Targeted Exercises Movements	Musical Resource
1	1	Baseline Evaluation	-	-	-	- Get up & Go - SARA - Music Therapy Questionary - WHOQOL – BREF.	-
	2	TIMP	Lying down	Adagio, increasing in 10% if patient condition and performance allows. 66-76 BPM.	Quaternary	A – Ocular Movement – To the Right, Middle, Left, Middle; B – Encephalic Movement - To the Right, Middle, Left, Middle; C – Inferior and superior limbs – Alternating limbs by time.	A – Recorded or performed, music therapist marking tempo verbally and with small percussion instruments such as caxixi; B - Recorded or performed, music therapist marking tempo verbally and with small percussion instruments such as caxixi; C - Recorded or performed, music therapist marking tempo verbally and with small percussion instruments such as caxixi; In the patient, sound bracelets on each limb.
2	3	TIMP	Lying down	Adagio, increasing in 10% if patient condition and performance allows. 66-76 BPM.	Quaternary	Repeat: A, B, C Add: D – Rolling trunk to the Right, Middle, Left, Middle.	Repeat: A, B, C Add: D – Positioning small instruments such as caxixis, and moving them from side to side.
	4	TIMP	Lying down	Andante, increasing in 10% if patient condition and performance allows 76-108 BPM.	Quaternary	Repeat: A, B, C, D.	Repeat: A, B, C, D.
3	5	TIMP	Lying down	Andante, increasing in 10% if patient condition and performance allows. 76-108 BPM.	Quaternary	Repeat: A, B, C, D.	Repeat: A, B, C, D.
			Sitting	Adagio, increasing in 10% if patient condition and performance allows. 66-76 BPM.	Quaternary	Repeat: A, B.	Repeat: A, B.
	6	TIMP	Lying down	Andante, increasing in 10% if patient condition and performance allows. 76-108 BPM.	Quaternary	Repeat: C, D.	Repeat: C, D.
			Sitting	Adagio, increasing in 10% if patient condition and performance allows.	Quaternary	Repeat: A, B. Add: E – Raising up knees alternately, right and left.	Repeat: A, B. Add: E – Recorded or performed, counting and giving verbal instruction if necessary. Positioning small instruments such as caxixis, and moving them from side to side.
4	7	TIMP	Sitting	Adagio, increasing in 10% if patient condition and performance allows. 66-76 BPM.	Quaternary	Repeat: A, B, E. Add: F – Releasing pelvic girdle by moving trunk sideways to the right, middle, and to the left, middle.	Repeat: A, B, E. Add: F – Positioning two large percussion instruments, such as congas, on the patient's sides, far enough apart to perform the movement.
	8	TIMP	Sitting	Adagio, increasing in 10% if patient condition and performance allows. 66-76 BPM.	Quaternary	Repeat: B, E, F. Add: G – Releasing pelvic girdle by rotating trunk to the right, middle, and to the left, middle.	Repeat: B, E, F. Add: G – Positioning two large percussion instruments, such as congas, on the patient's sides, far enough apart to perform the movement.
5	9	TIMP	Sitting	Andante, increasing in 10% if patient condition and performance allows. 76-108 BPM.	Quaternary	Repeat: B, E, F, G.	Repeat: B, E, F, G.
	10	TIMP	Sitting	Moderate. 108-120 BPM.	Quaternary	Repeat: B, E, F, G.	Repeat: B, E, F, G.
			Sitting down and standing up	Adagio, increasing in 10% if patient condition and performance allows. 66-76 BPM.	Binary	H – Standing up and sitting down with support of device in front of the chair.	H – Recorded or performed, counting and giving verbal instruction if necessary.
6	11	TIMP	Sitting down and standing up	Andante, increasing in 10% if patient condition and performance allows. 76-108 BPM.	Binary	Repeat: H.	Repeat: H.
			Standing	Andante, increasing in 10% if patient condition and performance allows. 76-108 BPM.	Quaternary	Repeat: A, B.	Repeat: A, B.
	12	TIMP	Standing	Andante, increasing in 10% if patient condition and performance allows. 76-108 BPM.	Quaternary	Repeat: A, B, F, G.	Repeat: A, B, F, G.
7	13	TIMP	Standing	Moderate, increasing in 10% if patient condition and performance allows. 108-120 BPM.	Quaternary	Repeat: A, B, F, G.	Repeat: A, B, F, G.
	14	TIMP	Standing	Adagio, increasing in 10% if patient condition and performance allows. 66-76 BPM.	Quaternary	Repeat: F, G. Add: I – Releasing shoulder girdle, by moving trunk back and forth.	Repeat: F, G. Add: I – Positioning percussion instruments, such as cymbals and chimes, in front of and behind the patient, in an adequate height for the movement.

Figure 1. *Proposal of music therapy protocol for ataxic patients – Part I.*

Week	Session	NMT Technique	Patient Position	Tempo (BPM) Beats per minute	Bar Form	Targeted Exercises Movements	Musical Resource
8	15	RAS	Standing	Adagio. 66-76 BPM.	Binary	J – Supported by a walker, walk for 1 meter, turn around, and return back.	J - Recorded or performed, counting tempo and giving verbal instruction if necessary.
	16	RAS	Standing	Adagio. 66-76 BPM.	Binary	K - Supported by a walker, walk for 2 meters, turn around, and return back.	K - Recorded or performed, counting tempo and giving verbal instruction if necessary.
9	17	RAS	Standing	Adagio. 66-76 BPM.	Binary	L - Supported by a walker, walk for 3 meters, turn around, and return back.	L - Recorded or performed, counting tempo and giving verbal instruction if necessary.
	18	RAS	Standing	Adagio. 66-76 BPM.	Binary	M - Supported by a music therapist at patient´ side, walk for 3 meters, turn around, return for 1 meter, and sit down in the chair positioned at the distance of 2 meters from the beginning.	M - Recorded or performed, counting tempo and giving verbal instruction if necessary.
10	19	RAS	Standing	Adagio. 66-76 BPM.	Binary	N - Supported by a music therapist at patient´ side, walk for 3 meters, turn around, return for 2 meters, and sit down in the chair positioned at the distance of 1 meter from the beginning.	N - Recorded or performed, counting tempo and giving verbal instruction if necessary.
	20	RAS	Standing	Adagio. 66-76 BPM.	Binary	O - Supported by a music therapist at patient´ side, walk for 3 meters, turn around, return 3 meters, and sit down in the chair positioned at the beginning.	M - Recorded or performed, counting tempo and giving verbal instruction if necessary.
11	21	RAS	Standing	Andante. 76-108 BPM.	Binary	P – Supported by music therapist, positioned behind the patient, lightly holding its shoulders. Walk for 1 meter, turn around and walk back, and sit down in the chair positioned at the beginning.	P – Recorded music, rhythm marked through the hands on the patient' shoulders.
	22	RAS	Standing	Andante. 76-108 BPM.	Binary	Q – Supported by music therapist, positioned behind the patient, lightly holding its shoulders. Walk for 2 meters, turn around and walk back, and sit down in the chair positioned at the beginning.	Q – Recorded music, rhythm marked through the hands on the patient' shoulders.
12	23	RAS	Standing	Andante. 76-108 BPM.	Binary	R – Supported by music therapist, positioned behind the patient, lightly holding its shoulders. Walk for 3 meters, turn around and walk back, and sit down in the chair positioned at the beginning.	R – Recorded music, rhythm marked through the hands on the patient' shoulders.
	24	RAS	Standing	Andante. 76-108 BPM.	Binary	S - Supported by music therapist, positioned to the patient´ side, with readiness for holding in case of patient unbalance. Walk for 1 meter, turn around, walk back, and sit down in the chair positioned at the beginning.	S – Recorded music, rhythm marked through the hands on the patient' shoulders.
13	25	RAS	Standing	Andante. 76-108 BPM.	Binary	T - Supported by music therapist, positioned to the patient side, with readiness for holding in case of patient unbalance. Walk for 2 meters, turn around, walk back, and sit down in the chair positioned at the beginning.	T – 1st part: Recorded music, rhythm marked through the hands on the patient's shoulders; 2nd part: no musical resource, marking rhythm on the patient' shoulders.
	26	RAS	Standing	Andante. 76-108 BPM.	Binary	U - Supported by music therapist, positioned to the patient side, with readiness for holding in case of patient unbalance. Walk for 3 meters, turn around, walk back and sit down in the chair positioned at the beginning.	U – no musical resource, marking rhythm on the patient' shoulders.
14	27	RAS	Standing	Moderate. 108-120 BPM.	Binary	Repeat: U.	Repeat: U.
	28	Final Evaluation	Standing	-	-	- Get up & Go - SARA - WHOQOL – BREF.	-

Figure 2. *Proposal of music therapy protocol for ataxic patients – Part II.*

Rhythm is a key element in each session of the protocol, providing the cues and stimulation required for the TIMP technique by requesting movements to be planned and timed. This supports the feedback-feedforward cycle. In the RAS technique, rhythm acts as a connector between the auditory and motor systems, facilitating synchronized movements, including those of the trunk and limbs, as required for gait [4].

At the end of the protocol, music resources are removed to verify the internalization of rhythm stimulation and to explore the potential for extending the benefits acquired to environments outside the music therapy clinic.

5. Conclusions

This study results in a music therapy protocol for patients with ataxia, based on Michael Thaut's NMT techniques, TIMP and RAS. It combines and systematizes these techniques, initially using TIMP to support oculo-encephalic, limb, and trunk movements, retraining, and exercising the feedback-feedforward signal process. Subsequently, the RAS technique is used to retrain and exercise balance and gait, aiming to improve patients' daily living activities and self-perceived quality of life.

The reproducibility of the protocol is ensured by defining each protocol variable, such as the music resources required for each session, the statistical methodology for sample size calculation, and the improvement measurements taken before and after protocol application.

Given the lack of available research and protocols for music therapy for ataxia, this study provides valuable literature on the topic. The protocol supports music therapists in the clinical treatment of ataxic patients.

The music therapy protocol for ataxic patients is ready for further application, enabling future contributions and expanding knowledge of the benefits of neurological music therapy for ataxic patients.

Abbreviations

TIMP	Therapeutical Instrumental Music Performance
RAS	Rhythmic Auditory Stimulation
CNS	Central Nervous System
ADL	Activities of Daily Living
NMT	Neuro Music Therapy
PD	Parkinson Disease
SARA	Scale for the Assessment and Rate for Ataxia
WHOQOL	World Health Organization Quality of Life Group
WHOQOL-BREF	World Health Organization Quality of Life Reduced Evaluation
MTQ	Music Therapy Questionary
BPM	Beats Per Minute

Author Contributions

Yuri Giffoni: Conceptualization, Methodology, Writing – original draft

Rita de Cassia Moura: Supervision, Writing – review & editing

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Data Availability Statement

Not applicable.

Conflicts of Interest

The authors declare no conflicts of interest.

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Biography

Yuri Giffoni holds a Bachelor's degree in Music Therapy from Faculdades Metropolitanas Unidas (FMU) (2021) and a specialization in Music Therapy from Faculdades Santa Marcelina (FASM) (2023). He has completed an extension course in Neurologic Music Therapy and presented an e-paper at the 17th World Congress of Music Therapy in Vancouver, Canada, in 2023. Additionally, he earned a degree in Chemical Engineering from Escola de Engenharia de Lorena (EEL/USP) (1999) and a Master of Science in Biomedical Engineering from Universidade do Vale do Paraíba (UNIVAP) (2005).

Rita de Cassia Moura holds a Bachelor's degree in Piano and Viola with orchestral experience, a degree in Physiotherapy, and a specialization in Physiology of Exercise from the University of São Paulo (USP). She earned her Master's and Doctorate in Health Sciences and Neurosciences from the Universidade Federal de São Paulo (UNIFESP). Dr. Moura is an author and contributor to articles and book chapters in research areas such as neurology and rehabilitation, focal dystonia in musicians, stroke, and music therapy. With extensive experience in education, she currently serves as the Coordinator of the Postgraduate Course in Music Therapy at Faculdade Santa Marcelina (FASM) and is an Ad Hoc reviewer for the journals Neuroscience, OPUS, and Hodie, focusing on occupational diseases in musicians and music therapy.

Research Field

Yuri Giffoni: Music therapy, neurologic music therapy, bioengineering.

Rita de Cassia Moura: Rehabilitation, neurologic music therapy, hospital music therapy, focal dystonia in musicians.