Active Music Therapy and Physical Improvements From Rehabilitation for Neurological Conditions

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ABSTRACT

Context • A variety of rehabilitation-based interventions are currently available for individuals with physical impairments resulting from neurological conditions, including physiotherapy, occupational therapy, and speech language pathology. Many individuals find participation in those therapies to be challenging. Alternative therapies have emerged as beneficial adjunctive treatments for individuals undergoing neurological rehabilitation, including music therapy (MT).

Objective • The study intended to identify and collate systematically the evidence on MT interventions that address physical improvements in a rehabilitative setting.

Design • The research team performed a literature review, searching electronic databases from their inception to April 2014, including Embase, CINAHL, PubMed, Scopus, and ProQuest. The review included original studies that examined the use of active MT as an intervention that promotes physical improvements for adults >18 y of age. Articles were excluded if the studies focused primarily on psychosocial, emotional, or spiritual therapeutic goals. The review identified the studies' outcome measures for different populations and the MT approaches and interventions and obtained a general description of the clinical sessions, such as the frequency and duration of the therapy, interventions performed, sessions designs, populations, equipment used, and credentials of the therapists.

Results • Eleven studies identified 2 major categories for the delivery of MT sessions: individual and group. One study included group sessions, and 10 studies included individual sessions. The studies included a total of 290 participants, 32 in the group MT, and 258 in the individual MT. The one study that used group therapy was based on active MT improvisation. For the individual therapy, 2 studies had investigated therapeutic instrument music performance and 8 used music-supported therapy.

Conclusions • The findings of the review suggested that active MT can improve motor skills and should be considered as a potential adjunctive treatment. (*Adv Mind Body Med.* 2016;30(4):14-22.)

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A variety of rehabilitation-based interventions are currently available for individuals with physical impairments resulting from neurological conditions. They include physiotherapy (PT), occupational therapy (OT), and speech language pathology.[1-3] Although the literature has demonstrated widespread benefits from participation in programs for neurological rehabilitation,[4] many individuals find participation in them to be challenging. Factors such as pain, fear, anxiety, or lack of motivation can serve as barriers to participation in traditional rehabilitative methods and prevent individuals from experiencing the full range of benefits possible from those therapeutic strategies.[5]

In response to the aforementioned barriers to participation, alternative therapies have emerged as beneficial adjunctive treatments for individuals undergoing neurological rehabilitation. Music therapy (MT) is a popular, evidence-based, alternative treatment that has recently been embraced as an effective adjunct to conventional rehabilitation programs targeting physical therapeutic goals.[6] MT may be particularly beneficial in facilitating physical improvements in populations with neurological impairments because of the many skills and cognitive processes that music requires.[7]

In the last 10 years, a number of studies have demonstrated that music listening, and to a greater extent music production—active MT where patients actively play an instrument—activate a multitude of brain structures involved in cognitive, sensorimotor, and emotional processing.[8,9] For example, music production requires a host of brain functions, including (1) reading a complex symbolic system, musical notation, and translating it into sequential, bimanual motor activity dependent on multisensory feedback; (2) developing fine motor skills coupled with metric precision; (3) memorizing long musical passages; and (4) improvising within given musical parameters.[10]

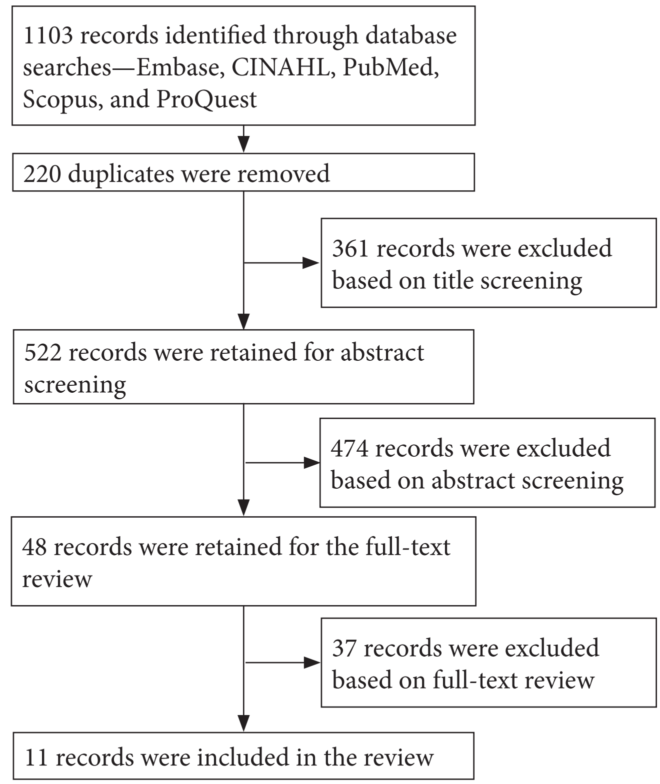
According to Altenmüller et al,[11] the multimodal effects of music production, together with music's ability to tap into the emotion and reward systems in the brain—such as in the frontal and parietal lobes, cingulate gyrus, amygdala, hippocampus, and midbrain—can facilitate the physical therapeutic benefits of neurological rehabilitation.

Malcom et al[12] have suggested that rhythm-based interventions that use a participant's ability to synchronize his or her movements to rhythmic auditory cues[13] can be an effective means of altering or influencing the timing of movement. That outcome is due to the strong physiological attractor function between auditory rhythmic cues and motor response, also known as entrainment.[14]

The entrainment phenomenon appears to facilitate auditory motor coupling, where motor movements synchronize to an external stimulus despite an injury or disease process.[15] It thus seems likely that automatic engagement of motor areas during rhythmic perception may be the connecting link between music and motor improvements.[16] That connection may occur because the temporal sensitivity of the auditory system, in combination with the strong temporal characteristics of music, can provide a regularizing temporal input to the motor system.[16] Zimmerman and Lahav[17] have reported that stroke patients who received musical training had significant improvements in speed, precision, and smoothness of movements. Zelazny[18] found that participants that played instruments improved finger strength. Other findings have suggested positive modifications in stride and symmetrical gait pattern among individual who had experienced a stroke[19] or who had Parkinson's disease.[20,21]

The successful use of music in rehabilitation relies not only on the patient's ability to synchronize with music but also on his or her existing motivation toward music and engagement in a meaningful and satisfying intervention.[22] Music can also serve as a distractor, and a patient's involvement in music may allow for transcendence to occur wherein the routine of regular exercise becomes an esthetic experience that is purposeful and meaningful.[5] Although the implications of active MT are generating great interest in the field, limited research to date has been published in the literature on physical and neurological rehabilitation.

Figure 1. Flow Diagram for Article Selection



METHODS

The current review systematically identified and collated the evidence on active MT interventions that targeted physical improvements in a rehabilitative setting. For music therapists and other health care practitioners interested in incorporating active MT into their clinical practices, its findings can provide an overview of the therapeutic technique and a summary of the current evidence that can serve to inform and facilitate clinical implementation.

The current review was performed based on the York methodology, as outlined by Arksey and O'Malley,[23] and it included the following 5 peer-reviewed databases: Embase, CINAHL, PubMed, Scopus, and ProQuest. Each database was searched from its inception to April 2014, using the following key search terms and Boolean operator commands: (1) *music therapy* AND *improvisation* OR *playing* OR *instruments* OR *production* and (2) *rehabilitation* OR *motor* OR *physical mobility* OR *movement*.

Articles were selected for inclusion in the review if they (1) reported on a primary study that had examined the use of active MT interventions that addressed motor skills among participants older than 18 years and (2) were written in either English or Spanish (Figure 1). Articles were excluded if the studies focused primarily on psychosocial, emotional, or spiritual therapeutic goals.

Table 1. Summary of Included Articles by Theoretical Approach

Article	Country	*N*	Mean Age (SD)	Gender M/F	Population	Theoretical Approach
Pacchetti et al[7] (2000)	Italy	16 MT 16 PT Con	62.4 (NR) 63.1 (NR)	12/4 11/5	PD	Group AMTI
Lim et al[34] (2011)	United States	16 MT 19 OT Con	79 (NR)[a]	9/26	Stroke, PD, OS	Individual TIMP
Chong et al[32] (2013)	Korea	5 MT	25.4 (4.9)	0/5	CP	Individual TIMP
Schneider et al[26] (2007)	Germany	20 MT 20 CG Con	58.1 (9.9) 54.5 (10.2)	8/12 5/15	Stroke	Individual MST
Altenmüller et al[27] (2009)	Germany	32 MT 30 CG Con	55.7 (12.3) 53 (11.8)	16/16 24/6	Stroke	Individual MST
Schneider et al[28] (2010)	Germany	32 MT 30 PT Con 15 FMT	55.7 (12.3) 53 (11.8) 56.1(10.7)	16/16 24/6 10/5	Stroke	Individual MST
Rojo et al[31] (2011)	Spain	1 MT	43	0/1	Stroke	Individual MST
Fujioka et al[33] (2012)	Canada	3 MT	65 (24.2)	3/0	Stroke	Individual MST
Grau-Sanchez et al[30] (2013)	Spain	9 MT	61.8 (9.8)	6/3	Stroke	Individual MST
Villeneuve et al[29] (2013)	Canada	15 CIT Con 3 MT	56.1 (10.7) 61.6 (4.7)	10/5 3/0	Stroke	Individual MST
Chong et al[25] (2014)	Korea	8 MT	13 (2.78)	6/2	Brain Injury	Individual MST

[a]Mean age reported was collapsed across MT and OT control groups.

Abbreviations: SD, standard deviation; MT, music therapy; NR, not reported; PD, Parkinson's disease; Con, control; AMTI, active music therapy improvisation; OT, occupational therapy; OS, orthopedic surgeries; TIMP, therapeutic instrument music performance; CP, cerebral palsy; CG, conventional treatment; MST, music-supported therapy; FMT, functional motor training; PT, physical therapy; CIT, constraint-induced therapy.

The review identified the studies' outcome measures for different populations and the MT approaches and interventions and obtained a general description of the clinical sessions, such as the frequency and duration of the therapy, interventions performed, sessions' designs, populations, equipment used, and credentials of the therapists.

The search was conducted by the author DK and initially yielded 1103 results. After duplicates were removed, it yielded 883 unique abstracts. The process of selecting articles for inclusion in the study began with articles being screened by one reviewer (DK) by title and abstract. Those articles whose titles or abstracts identified active MT as a focus of the research ($N = 48$) had their full text reviewed by 2 researchers independently (DK and ER). Rare discrepancies were resolved by consensus and, if required, by review from a third rater (JH). Thirty-seven records were excluded based on full text review and key information from the remaining 11 articles was then extracted and charted by (DK and JH), and important results were thematically coded.

RESULTS

The search identified 11 relevant articles (Table 1). From those articles, 2 major categories emerged: group MT sessions and individual MT sessions. One study used group sessions, and 10 studies used individual sessions. Within those categories, a number of theoretical subcategories of MT approaches had been investigated, including (1) active MT improvisation (AMTI), (2) therapeutic instrument music performance (TIMP), and (3) music-supported therapy (MST).

The sole study that delivered MT in a group setting was based on the AMTI approach. Among the studies using individual MT sessions, 2 investigated TIMP and 8 evaluated MST. The studies included a total of 290 participants, 32 for the group MT, and 258 for the individual MT. The studies had been conducted in various countries: (1) 1 individual TIMP study in the United States; (2) 1 group AMTI study in Italy; (3) 2 individual studies in Korea, one examining TIMP and the other MST; (4) 2 individual MST studies in Spain; (5) 3 individual MST studies in Germany; and (6) 2 individual MST studies in Canada.

Table 2. Summary of Research Using Group Music Therapy

Article	Aim	Design	Outcome Measures	Important Findings
Pacchetti et al[7] (2000)	Primary: Efficacy of MT on motor involvement in PD compared with PT	Single, blind RCT	UPDRS bradykinesia, rigidity, ADLs	Baseline and postintervention values indicated that MT led to significant improvements in bradykinesia and ADLs, whereas PT led only to significant improvements in rigidity. Improvements were no longer evident at 2 mo postintervention for both MT and PT groups.

Abbreviations: MT, music therapy; PD, Parkinson's disease; PT, physical therapy; RCT, randomized, controlled trial; UPDRS, unified Parkinson's disease rating scale; ADLs, activities of daily living.

The results of the group MT study were published in 2000. The 2 TIMP articles were published in 2011 and 2013, and the MST articles were published between 2007 and 2014. Those dates indicate that the research on a group MT intervention addressing physical rehabilitation was last completed 14 years before the current review. Thus, at the time the current literature search was undertaken, only TIMP and MST interventions were being researched.

Group MT

Active MT Improvisation. The AMTI approach designed by Pacchetti et al[7] is a structured 13-week program that is delivered in weekly 2-hour sessions with groups of 8 participants. During each therapy session, participants engage in a variety of activities, including listening and relaxation exercises, movement to music, vocalization exercises, instrument playing and improvisations. Although structured, the therapist is afforded some flexibility in the design and implementation of the interventions delivered.

For this approach, it is recommended that a session room be of sufficient size for participants to hear and move easily. Typically, the central area of the room is left empty so that room for movement activities is available as well as space to put the instruments during improvisations. The equipment required typically includes a piano, an organ, percussion instruments, a Hi-Fi system with record and compact disc player, a mixer, an audio recording system and microphones, and a video camera for recording.

At the beginning of each session, participants are first invited to sit comfortably for a listening and relaxation intervention. They listen to music and visualize peaceful images for approximately 10 to 15 minutes. During that time, they are asked to breathe continuously without inspiratory or expiratory pauses, as though their breathing is part of the music. The therapist then invites the group to stand up, and he or she leads the stretching of muscles and joints. Movements are always synchronized to the music. The music used for this section is usually from the new age genre. A wide variety of styles of new age music exists, but, very often, the music is dreamy and associated with nature, featuring sounds of waterfalls, ocean waves, and animals combined with Celtic harps, sitars, and digital synthesizers. It tends to be slow.[24]

Following the listening and relaxation intervention, participants are then invited to accompany music with hand gestures; their hands are moved up and down the body from the abdomen to the head. Subsequently, participants are invited to make vocal sounds, onomatopoetic sounds, and extreme sounds (high-low) and to perceive corresponding points of bodily vibration. While singing, participants are also invited to activate and exaggerate the use of their muscles for facial expressions by shouting, whispering, and pronouncing the notes. Other techniques are employed, such as adjusting the pitch to match other voices and listening to the self and others to achieve euphony and produce collective vocal harmonies.

The main part of each session is based on improvisation. First, all participants are allowed to practice freely using instruments and voice, play music games, and use free expression with the body. Then, they must seek to interact with one another. The therapist acts as a conductor, stimulating the group, suggesting short rhythmic-melodic ideas. Finally, the therapist leaves the group free to reach a musically uncontrolled conclusion based on the spontaneous contribution of each instrumentalist. The aim of the exercise is to create a musical sound progressively with a strong element of emotional involvement, where every person shares his or her own physical and psychological sensations with the group. Each improvisation lasts 30 or 40 minutes, on average.

The one study included in this review that used the AMTI approach was conducted by Pacchetti et al[7] in 2000. In their study, trained music therapists who had obtained a recognized bachelor's degree or graduate certificate and had successfully completed the accreditation process for their provincial or federal agency delivered the group MT intervention. Each of the sessions were 90 minutes in duration and occurred weekly in the course of 3 months.[7] Participants were individuals with Parkinson's disease (PD) and the instruments used were metallophones, xylophones, drums, wood block, and cymbals. The study compared a control PT group with the MT group. The study[7] was randomized, controlled, and single-blinded.

Although the study provided some details on how the MT session was designed and applied, the level of detail was not sufficiently specific, thus leaving open the possibility for interpretation. No long-term follow-up beyond 2 months was reported in the study. The outcome measures focused on the changes in the number of physical responses during the musical activities by assessing motor functions, including bradykinesia and rigidity using the unified PD rating scale-motor scale.[7] The study's aim, design, outcome measures, and results are presented in Table 2.

Individual MT

Therapeutic Instrument Music Performance. The TIMP technique from the neurologic MT program designed by Michael Thaut comprises 30- to 40-minute sessions and uses instruments to reinforce functional motor patterns. In this approach, instruments are used not only to produce musical output but also to facilitate movement associated with nonmusical rehabilitative purposes. For example, the therapist might place various sizes of drums at different heights and direct a patient to extend his or her arm to play the drum at different spatial locations. The aim of this approach is to help to train eye-hand coordination; increase motor planning and coordination of the upper extremities bilaterally; improve range of motion of the elbow, shoulder, or wrist; and increase muscular strength and endurance.[36] To deliver the TIMP approach, one must obtain a recognized MT bachelor's degree or graduate certificate and have successfully completed the accreditation process for their provincial or federal agency, and he or she must receive certification as a master in neurological music therapy.[14]

One example of an investigation that used the TIMP approach is the study by Lim et al,[34] wherein participants completed a functional target moving task. Specifically, participants were placed in a seated position with full elbow flexion or extension with the shoulder flexed to 90 degrees. A light mallet with a 1-pound (0.45 kg) weight was added to the patient's wrist, targeting a paddle drum. With an assistant holding the paddle drum directly above eye level so that the participant's shoulder was flexed to 90 degrees, the investigator demonstrated the target movement by flexing to tap his or her own shoulder, extending to strike the drum, then repeating the sequence. The participant was instructed to touch his or her shoulder, hit the drum, and then repeat the sequence at a comfortable pace. The music and exercise were stopped when the patient stated that he or she was too fatigued or in too much pain to continue. For one specific intervention in their study, Lim et al[34] arranged a 7-minute instrumental version of 3 songs: the traditional "I've Been Working on the Railroad," Stephen Foster's "Swanee River," and Irving Berlin's "Alexander's Ragtime Band." The arrangements were recorded and played through a Yamaha keyboard, and the music was arranged with strong emphasis on the down beats, especially specific metric and rhythmic features, to facilitate the desired movements. The investigator measured and recorded the number of repetitions of the movement sequences as well as the duration of the exercise.

Music-supported Therapy. The MST technique comprises sessions that are generally 25 to 30 minutes in duration that focus on musical training of familiar melodies. Required equipment includes an 8-pad electronic drum set and/or an electronic piano that produces the sounds A, B, C, D, E, F, and G.[33] When using the drum set, the 8 drum pads are arranged from left to right in a half circle so that the patient can reach all from a central position.[27] Both the drum set and piano are programmed using a musical instrument digital interface (MIDI) and software. The music that is made is digitally transferred via the MIDI, such that music from each instrument provides data on a scale of sound loudness, from 1 to 127. Fine and gross motor skills are assessed and trained on the piano and drum set respectively. No specific formal training is required to deliver MST.

The most recent example of a study that used a MST approach included within this review is provided by Chong et al.[25] In their investigation, musical training involved participants making music on a Yamaha electronic keyboard during two 25-minute sessions per week for 4 to 6 weeks. To allow individuals to participate who had no previous music experience or keyboard training, the authors marked the keyboard with numbered stickers and used a numbering system to indicate finger sequence.

During each session, participants played simple melodic patterns that were based on repeated movements of a single finger such as thumb-thumb-thumb-thumb, and successive movements of adjacent fingers, such as thumb-index-middle-ring-little. As each participant became accustomed to keyboard playing, random movements of the fingers or combinations of more than 2 finger movements were executed.

Of the studies in the current review that adopted an individual MT approach, 3 were conducted by an accredited music therapist including both TIMP interventions[32,34] and 1 MST study.[25] The remaining 7 MST studies included in the review were conducted by therapists from other disciplines such as faculty in music and drama,[26-28] physical[29] and occupational therapists,[30] and neurophysiologists.[31] One study did not report on the professional background of the instructor who delivered the intervention.[33] The length and duration of the individual MT sessions and programs ranged from biweekly 30-minute sessions in the course of 3 months[32] to five 30-minute sessions per week in the course of 5 weeks for a total of 25 sessions.[33] One study[34] did not report the length of sessions.

Participants included those with cerebral palsy[32] or neurological disorders such as PD, those who had had orthopedic surgeries, those with general physical deconditioning,[34] those who had had a stroke[27-31,33,35] or an acquired brain injury.[25]

Five studies compared groups receiving OT, PT, and conventional treatment and healthy control groups against an MT group,[26-29,34] whereas the remaining 5 studies did not include group comparisons.[25,30-33] Five studies employed repeated measures designs[25,29,30,32,33]; 2 employed a randomized, controlled, single-blinded design[28,34,]; 1 used a pseudorandomized, controlled design[26]; 1 was a case study[31]; and 1 was a prospective cohort study.[27] Only 1 study[34] described in detail how the TIMP session was designed and applied so that the reader could replicate it. All MST studies provided an in-depth description of the methodology used, such that the study's protocol could be replicated in future investigations. No long-term follow-up was reported in any of the studies.

The TIMP outcome measures focused on changes in hand functioning,[32] endurance, self-perceived fatigue, and self-perceived exertion.[34] Those outcomes were measured using the MIDI,[32] analyzing video sessions, and having participants complete the Patient Perceived Fatigue Scale and Ratings of Perceived Exertion.[34]

The MST outcome measures predominantly focused on changes in the pressing velocity of the fingers and on hand function,[25] fine and gross motor skills,[27-29,31,35] and changes in the sensorimotor representations underlying motor gains.[30] Those outcomes were measured by employing the Grip and Pinch Power Test,[25] Box and Block Test of Manual Dexterity,[25-31] Jebsen-Taylor Hand Function Test,[25,29] 9-Hole Pegboard Test,[27-31] Action Research Arm Test,[26-28,30,31,33] Arm Paresis Score,[27,28,30,31] and Transcranial Magnetic Stimulation Test.[31] The aims of the 10 individual MT interventions and their designs, outcome measures, and results are presented in Table 3.

Table 3. Summary of Research Using Individual MT Interventions

Article	Aim	Design	Outcome Measures	Important Findings
Lim et al[34] (2011)	To examine whether an active musical experience as compared with traditional OT treatment influenced the perception of endurance, fatigue, and exertion among individuals with neurologic impairment or orthopedic surgery	RCT (within subjects)	• Endurance: Exercise duration and number of exercise sequences on a functional target movement task • Fatigue: Patient-perceived fatigue scale • Exertion: Rating of perceived exertion scale	• No difference in endurance was found between TIMP and traditional OT treatment • TIMP resulted in significantly lower levels of perceived fatigue and exertion than traditional OT
Chong et al[32] (2013)	• To examine the effects of TIMP training on hand function among adults with CP • To compare hand function of adults with CP to that of HA	Case series, repeated measure	Key pressing velocity on a keyboard using Cubase 6 MIDI program	• Following TIMP training, velocity of key pressing for each digit improved; however, the pre-post differences were not statistically significant • Prior to TIMP training, velocity of key pressing for each digit among adults with CP was significantly slower compared with that of HA • Following TIMP training, velocity of key pressing for the second and fifth fingers among adults with CP increased such that a significant difference compared with HA no longer existed
Schneider et al[26] (2007)	To evaluate the effect of an MST training program on U/E movements in stroke patients	Pseudo-RCT	• Computerized movement analysis of whole hand tapping and finger tapping • ARAT, APS, BBT, 9HPT	• Frequency, velocity, and smoothness for both hand and finger tapping tasks significantly improved with MST but not with conventional therapy alone • All measures—ARAT, APS, BBT, and 9HPT—significantly improved with MST but not with conventional therapy alone
Altenmüller et al[27] (2009)	To assess whether neural reorganization can be induced by MST	Prospective cohort study	• Physiological measures: ERD/ERS, coherence • Behavioral measures: CMA, ARAT, APS, BBT, 9HPT	• ERD/ERS and coherence significantly improved with MST but not with conventional therapy alone • All measures—CMA, ARAT, APS, BBT, and 9HPT—significantly improved with MST but not with conventional therapy alone
Schneider et al[28] (2010)	To evaluate the effectiveness of MST compared with conventional treatment and functional motor training for recovery of motor function in the upper extremities in stroke patients	RCT	• Motor function: ARAT, APS, BBT, 9HPT • Computerized movement analysis: Frequency, average max angular velocity, and number of inversions of velocity profiles during whole hand tapping, index finger tapping, and forearm pronation/supination movements	• The MST group performed significantly better following the intervention on ARAT, APS, BBT, and 9HPT compared with both conventional-treatment and functional-motor-training groups • Following the intervention, the MST group demonstrated a significant increase in finger tapping frequency compared with both conventional-treatment and functional-motor-training groups • Gross motor skills—pronation and supination of forearm—did not significantly improve following the intervention in any of the therapy groups (MST, conventional treatment, or functional motor training)

Table 3. (continued)

Rojo et al[31] (2011)	To present evidence of neuroplastic changes in a stroke patient following MST	Single case study	• Motor function: ARAT, APS, BBT, 9HPT • Computerized movement analysis: Frequency, amplitude, max angular velocity, symmetry velocities, and smoothness of acceleration profiles during whole hand tapping, index finger tapping, and forearm pronation/supination movements • TMS: Coordinates of hot spot, resting motor thresholds, silent period, recruitment curve, motor maps, peak-to-peak amplitude, and latency of the max MEP and center of gravity • fMRI: Activation levels in each hemisphere of 6 regions of interest: primary motor cortex; supplementary motor area and premotor cortex; anterior cingulate cortex; cerebellum; superior parietal cortex; and inferior parietal cortex, during sequential movements with index and middle fingers of each hand	• Improvements following MST were noted for grasp, grip, and pinch subsections of the ARAT • No improvements following MST were noted for APS, BBT, or 9HPT • Significant improvements were noted in hand tapping frequency and finger tapping smoothness • Nonsignificant improvements were noted in finger tapping frequency and hand tapping smoothness • TMS and fMRI indicated plastic changes in contralateral sensorimotor cortex following MST as evidenced: o By TMS: Showed increased amplitude of motor-evoked potentials in both hemispheres, increased slope of recruitment curve in affected hand, lower resting motor threshold and smaller map area in affected hand, and increased map area in both hemispheres posttherapy o By fMRI motor task: Showed decrease of activation in the contra- and ipsilateral sensorimotor areas and secondary premotor regions and dramatic increase in lateralization index of primary motor cortex following MST
Fujioka et al[33] (2012)	To evaluate the effect of MST on the functional reorganization of auditory motor communication in chronic stroke patients	Case series, repeated measure	• Behavioral motor skills: ARAT, finger tapping test, grooved pegboard test, Purdue pegboard pest • MEG recording	• MST resulted in improvements to each patient's ARAT score, and in 2 patients, the finger-tapping test score • Two-thirds of patients were unable to complete either the grooved or the Purdue pegboard tests; thus, no results were reported • MST significantly changed amplitude of beta power change • Pre- and post-MST MEG recordings indicated functional cortical reorganization in beta-band networks • Event-related beta decrease was enhanced after MST training
Grau-Sanchez et al[30] (2013)	• To evaluate the effect of an MST training program on U/E motor function in subacute stroke patients • To examine whether restoration is followed by neuroplastic changes in the sensorimotor cortex	Case series, repeated measure	• Motor function: ARAT, APS, BBT, 9HPT • Cortical excitability: TMS motor evoked potentials from the first dorsal interosseous	• Following MST, significant improvements were found in ARAT, APS, and BBT • No differences were found in the 9HPT • Improvements in motor function were accompanied by neuroplastic changes, as evidenced by significant improvements in the active motor threshold, mapping area, and center of gravity coordinate
Villeneuve et al[29] (2013)	To determine the short- and long-term effects of a 3-wk MST training program on U/E function in chronic stroke patients	Case series, repeated measure	• Fine manual: 9HPT • Gross motor dexterity: BBT • Functional U/E use: JTHFT	• After the intervention, all participants showed improvements in their fine and gross motor dexterity and in the functional use of their U/Es • Postintervention improvements on the NHPT, BBT, and JTHFT were maintained at 3-wk follow-up

Table 3. (continued)

Chong et al[25] (2014)	To evaluate the effects of MIDI keyboard playing on finger movement for adolescents with brain damage	Case series, repeated measure	Key pressing velocity on a keyboard using MIDI, GPPT, BBT, JTHFT	• Following MST, increased key pressing velocity was observed for all fingers, with differences being statistically significant for fingers 2, 3, and 5 • Following MST, scores on the GPPT, BBT, and JTHFT improved, with differences being statistically significant only for a simulated feeding subtask within the JTHFT • Following MST, strong correlations were noted between grip power and pressing force for fingers 2 and 5, between MIDI and BBT for all fingers, and between moving light objects on the JTHFT and MIDI for all fingers.

Abbreviations: MT, music therapy; OT, occupational therapy; RCT, randomized controlled trial; TIMP, therapeutic instrument music performance; CP, cerebral palsy; MIDI, musical instrument digital interface; HA, healthy adults; MST, music-supported therapy; U/E, upper extremity; ARAT, action research arm test; APS, arm paresis score; BBT, box and block test; 9HPT, 9-hole pegboard test; ERD, event-related desynchronization; ERS, event-related synchronization; CMA, computerized movement analysis; TMS, transcranial magnetic stimulation; MEP, motor-evoked potentials; fMRI, functional magnetic resonance imaging; MEG, magnetoencephalography; JTHFT, Jebsen-Taylor hand function test; GPPT, grip and pinch power test.

DISCUSSION

Recent literature has suggested that MT is a beneficial adjunctive treatment for individuals undergoing physical and neurological rehabilitative treatment. The current review is the first study to summarize active MT treatments that address physical mobility for those in rehabilitation. The results of the current study indicated that the majority of MT reports lacked important details pertaining to the design and implementation of the MT sessions. Results also indicated that MST which does not require an accredited music therapist, is the intervention that demonstrated the most significant results in improving fine and gross motor skills and had the largest number of published studies.

Other studies focused on outcome measures such as emotional state and motor functions[7] and duration of rhythmic auditory entrainment.[34] Even though those outcome measures are somewhat related to motor skills, no correlations were made other than for factors that measured bradykinesia, rigidity, and postural and resting tremor in the study by Pacchetti et al.[7] The only other study that measured finger velocity and accuracy was conducted by Chong et al,[32] but their MT approach was rather similar to MST instead of TIMP.

Overall, the small number of articles included suggests that a limited amount of research has occurred on the effectiveness of active MT treatments in addressing physical mobility. In a systematic review conducted by Weller and Baker,[37] which examined the role of MT in physical rehabilitation for a variety of conditions, ages, and MT interventions—such as exercise to music, rhythmic auditory stimulation, and auditory cues and not only active MT for adults—concluded that a limited, moderate level of evidence indicates that therapy involving music, both active and passive, can be clinically effective in treatment for physical rehabilitation of adults.

Furthermore, the only research study on a group MT intervention was performed 14 years ago, and, since then, most of the individual MT interventions investigated MST, wherein the intervention was conducted by individuals who were not trained as accredited music therapists. That fact can be explained by the relatively small number of music therapists as compared with individuals in other health professions[38] or by the difficulties of standardized treatment when most MT interventions are based on the therapeutic relationship[39] and are modified according to patients' responses.[40] In some instances, evidence-based methods investigating clinical areas in MT have been questioned and discouraged.[41]

Although all studies included in the current review were conducted within short periods—less than 6 months—with relatively small sample populations—from 1 to 77 participants—the information can form the basis for future research into the beneficial effects of active MT on physical rehabilitation. Although the majority of studies did not yield statistically significant results to demonstrate that active MT was superior to other treatments, the findings of the current review provide insight into the breadth of research on the topic and can inform future research in the area.

That information is particularly important because many music therapists exclusively employ approaches using improvisational live music in neurological rehabilitation, despite relatively few published studies in the area.[42] The literature also demonstrated a dearth of published research findings from studies that examined individual MT improvisation, where participants actively play and improvise music[43] without combining the approach with other interventions such as relaxation or music and movement.

Individual MT improvisations, as well as TIMP, MST, and other new designs need to evolve to optimize the components of the interventions, test specific outcome measures, and assign individual or small groups of participants randomly to intervention or control groups. As such, they can build toward and inform the design of more rigorous protocols, which then can establish the generalized efficacy of the intervention across sites as well as of different treatment intensities, thus leading to new evidence-based interventions modeled in MT.

Active MT, applied to physical rehabilitation, is still a relatively new treatment modality. Only a limited number of studies have been conducted concerning its clinical effectiveness to date. In addition, the variability in the application with the use of different MT approaches to achieve a variety of outcomes makes analysis of studies into its effectiveness difficult, as often the interventions are different.

CONCLUSIONS

The findings of the current review suggest that active MT can improve physical mobility and that it can be an adjunctive treatment to existing treatments. It is important to note, however, that the benefits of MT, as reported in the reviewed studies, have yet to be supported by adequate evidence from high-quality, adequately powered studies. Ideally, those studies should be controlled and multicentered, include adequate sample sizes, and follow participants for at least 6 months. In addition, the cost-effectiveness of active MT compared with other interventions in physical rehabilitation should be assessed.

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