

Narrative Review Article

Dance Movement Therapy and Executive Function in Multiple Sclerosis: A Literature Review

Bella Brumana

Leland High School, 6677 Camden Ave, San Jose, CA, 95120, United States

ABSTRACT

While the physical impairments of multiple sclerosis are commonly acknowledged and targeted for treatment, cognitive impairments, including executive function deficits, often receive less recognition. Although pharmacological treatments are the main form of disease mitigation, non-pharmacological therapies are another promising management method that can address both cognitive and physical deficits. Dance movement therapy is an emerging intervention that has been commonly used in neurodegenerative disease rehabilitation, multiple sclerosis included. This literature review examines the effect of dance movement therapy on executive functions in multiple sclerosis patients through the analysis of four key studies that implemented varying dance modalities with some emphasis on executive function measures. Despite differences in the methodology, duration, and type of cognitive assessments, all four studies demonstrated executive function improvements which can suggest that the memorization of choreography, coordination, and dual tasking involved in dancing contribute towards executive function engagement. While these are promising findings, this review also emphasizes the need for more research that can incorporate larger sample sizes and various executive function standardized measures to obtain a better understanding of the benefits of dance movement therapy for multiple sclerosis.

Keywords: multiple sclerosis; executive functions; dance movement therapy; treatment; cognition

INTRODUCTION

According to the Atlas of Multiple Sclerosis (MS) (1), the number of people worldwide with MS has increased from 2.3 million in 2013 to 2.9 million in 2023. This means that 1 in 3000 people are living with MS across the globe. MS is a neurodegenerative,

disabling disease that is increasingly targeting young adults, most commonly women (2). In MS, the body's immune system attacks the myelin sheaths that protect nerves in the brain and spinal cord, disrupting nerve signals. This leaves various lesions that have led to the name, multiple sclerosis or *scars*. The disorder can either occur in remitting relapses or through progressive development without plateaus of recovery (3). MS has been found to be most prevalent in North America and Western Europe (4). In the prevalence rates between gender differences, the number of females with MS is often almost double the number of males with MS across various world regions. While there is no definitive reason for this, the genetic and hormonal differences

Corresponding author: Bella Brumana, E-mail: bellabrumana@icloud.com.

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between women and men likely create higher risk for women to be diagnosed with MS. Additionally, women are twice as likely to be diagnosed with MS than men, specifically between the ages of 15-40 years. For both males and females, the age distribution rises from ages 10-34 and begins to decrease afterwards, reaching a plateau after the age of 60.

Various causes of development for MS—in combination with genetic predisposition—have been identified as vitamin D deficiency, childhood obesity, smoking, and infection of the Epstein-Barr virus (2). MS manifests itself in relapses that can occur for mere hours or up to multiple days, eventually reaching a stopping point of recovery, or a plateau. This leads to subtypes of MS including relapsing remitting MS (RRMS), primary progressive MS (PPMS), secondary progressive MS (SPMS), and progressive relapsing MS (PRMS). Across these subtypes, common symptoms include impaired balance, impaired gait, impaired mobility, ataxia, fatigue, bladder dysfunction, and visual impairment (5). Diagnosing MS is an intricate process that involves medical history, magnetic resonance imaging (MRI), lumbar punctures, evoked potentials, and blood sample analysis before confirming a diagnosis (3).

The areas of cognitive impairment most affected include executive functions (EF)—skills crucial for control and coordination—, short-term and long-term memory, visual spatial abilities, and verbal fluency (6). These deficits can also be caused by preexisting mental health disorders such as depression. To mitigate these symptoms, there are pharmacological and non-pharmacological treatment options for MS. There are various disease-modifying therapies including injectable medications and oral medications that reduce the severity and frequency of relapses (7). Non-pharmacological options include exercise, physical therapy, yoga, aerobic training, and dance movement therapy (DMT) (8).

DMT uses dance as a psychotherapeutic form of movement targeted towards improving cognitive, physical, and social aspects of those participating (9). As Susan T. Loman (9), a DMT specialist, puts it, DMT “is a form of psychotherapy that utilizes movement as the medium of interaction and intervention promoting change.” One of the most commonly treated neurological conditions with DMT is Parkinson’s disease, which has shown improvements in gait, mobility, motor control, and balance. Tango is a popular dance style used in these dance programs, challenging participants with complex

step patterns and rhythmic coordination (10). DMT has even proven to benefit mood and psychiatric conditions due to the physical exercise and social engagement aspect of group dance classes. Reduced depression, stress, anxiety, and improved self-esteem are just some results following dance therapy interventions (11).

When it comes to DMT for MS, there is a lack of literature and studies in comparison to other neurodegenerative diseases, like Parkinson’s (11). Most of the limited information is based on pilot or feasibility trials with very small sample sizes and varying study designs. Despite this, the existing interventions report similar findings of improved balance, gait smoothness, quality of life, and even EFs apart from other motor functions (12). However, there is still a lack of standardized EF assessments as many studies tend to focus on the motor and physical outcomes rather than cognitive outcomes. Due to this gap, this literature review intends to synthesize the existing research on DMT for MS with a focus on how it can influence executive functioning, a very important set of cognitive skills that tend to face impairment in MS. Different studies will be compared on the basis of dance intervention style, program duration, rigor and assessment measures, in order to analyze how these aspects of a study can influence the observable outcomes. By highlighting the limitations in the present literature, this review can lay the groundwork towards future research that can address and mend these knowledge gaps, creating accessible studies highlighting EF outcomes in DMT interventions for MS patients.

COGNITIVE AND MENTAL HEALTH CHALLENGES IN MULTIPLE SCLEROSIS

Apart from the physical impairments that arise, MS patients also exhibit various cognitive deficits due to brain lesions that interrupt nerve signals that are essential to the processes (13). MS patient symptom profiles have a wide variation when it comes to what types of symptoms each person experiences individually. Cognitive deficits can also occur independently from physical impairments which can sometimes lead to less effective diagnosis of the disease. MS impairs several cognitive functions such as attention, information processing, processing speed, long-term memory and EFs. Although EFs in MS patients are less affected than memory or processing speed, there can still be the presence of significant deficits. More specifically,

shifting, inhibition, organization and fluency have all been found to be affected by MS. There is also a lack of efficiency when it comes to the manipulation of information over a shorter period of time, referred to as working memory.

Those with MS also struggle with attention processes, those that directly involve processing speed and executive control. In fact, in a study done by Genova *et al.* (14), it was concluded that the performance of executive tasks by MS patients depends greatly on processing speed. In their study, two tests to measure executive functioning were used, Trail Making and Color-Word Inference, with the influence of processing speed factored into the tests. The MS group performed slower in terms of processing speed and executive functioning during this initial trial. Once processing speed was taken out of the equation for the EF results, there were less significant differences. It is important to note that cognitive deficits other than those impacting EFs can exacerbate preexisting executive dysfunctioning.

A deeper analysis of EF impairment in MS demonstrates that certain EFs are more vulnerable than others. In a study completed by Cerezo García *et al.* (15), it was concluded that cognitive flexibility, inhibition, and abstraction ability were the most affected components of EFs. This study performed a variety of tests on 100 MS participants and 30 controls that were used to compare results with. There was a significantly lower performance in the Comprehensive Trail Making Test (CTMT), Stroop Test (STROOP), and Wisconsin Card Sorting Test (WCST) in MS patients, compared to the control group.

CTMT tested cognitive flexibility, STROOP tested inhibition, and WCST tested both cognitive flexibility and abstraction. The findings from the highlighted studies underscore how EFs are a set of cognitive functions particularly targeted in cases of MS.

Along with the various cognitive deficits that can occur, psychiatric disorders and mental health disorders are common amongst MS patients. According to Silveira *et al.* (16), about 25-50% of MS patients suffer from major depression, a value that can be up to five times greater than the general population.

Apart from the mental stress that is placed on those with MS, there are also neurobiological risk factors that can increase the prevalence of such depressive disorders. The various lesions in areas of the brain such as left arcuate fasciculus, prefrontal cortex, anterior temporal lobe, and parietal lobe are all associated with

depression found in MS patients. Those with more lesions in the spinal cord tend to not be diagnosed with depression as commonly as there is less damage done to the brain. Additionally, depression affects various cognitive functions, including executive functioning (13). Already impaired functions can be further worsened by depressive disorders, potentially masking the root cause by MS.

Beyond depression, other disorders such as anxiety, bipolar disorder, schizophrenia, and obsessive-compulsive disorder are also commonly diagnosed psychiatric disorders in MS (17).

TREATMENT FORMS

Although there is no current cure for MS, there are several forms of treatment that are used to mitigate the disorder. The most common and standard course of treatment is through medication. In the early 1900s, IFN β and glatiramer acetate injections became the first form of treatment for RRMS, targeted to reduce the amount of annual relapses, since both have anti-inflammatory properties. These forms of treatment were crucial in jumpstarting the pursuit to more possibilities toward MS remedies, leading to the first monoclonal antibody natalizumab. In the early 2010s, oral drugs started to gain popularity, with fingolimod being the first oral drug to be approved, reducing annual relapse rates by 50% and reduced disability accumulation by one-third. The most commonly used oral drug for MS is dimethyl fumarate which reduced the annual relapse rate by 50% and reduced the risk of EDSS progression by 35% (7).

On the other hand, there are additional non-pharmacological therapies that can target cognitive functions while even providing physical exercise. Aerobic training (AT), for example, has shown to improve executive control, can reduce age-related atrophy, and may increase hippocampal volume as a result of increased levels of molecules that stimulate dendritic network. AT also addresses physical concerns in terms of preventing osteoporosis, cardiovascular issues, obesity, and irregular glucoregulation. Without putting much stress on the body, AT is a promising form of additional treatment for MS patients (8). Another option is hydrotherapy that can offer even less stress on the body. In a study done by Castro-Sánchez *et al.* (18), Ai Chi water exercises were evaluated over the course of 20 weeks. By the end of the trial, the treatment group showed significant pain reduction, a

decrease in the Roland Morris Disability Questionnaire scores, a decrease in spasm visual analogue scores, and a reduction in the Multiple Sclerosis Impact Scale 29 psychological score. There are also several other emerging therapies that are less widespread but available for patient use. One of those includes brain stimulation techniques such as Transcranial Direct Current Stimulation (tDCS), Transcranial Magnetic Stimulation (TMS), and Deep Brain Stimulation (DBS) (8). TMS and tDCS are more frequently utilized and they can help enhance recall speed when used in the anterior temporal lobe. tDCS has also been proven to enhance executive functioning, working memory as an example, and learning. TMS works to enhance cognitive skills by stimulating brain plasticity and activating motor areas. DBS is an invasive procedure that can directly alter memory systems and improve tremor control post long-term treatment.

DANCE MOVEMENT THERAPY

Marian Chance, a Denishawn dancer of the 1930s, was one of the main pioneers to bring DMT to the public eye (9). Dance styles utilized in DMT include ballroom, salsa, tango, square dancing, and more. DMT has been proven beneficial for several conditions including cancer, brain health, and cardiovascular disease (19). DMT, however, is more commonly used to treat those with neurodegenerative disorders, with Parkinson's and mild cognitive impairment (MCI) as some frequent examples. In neuroimaging studies investigating the effects of DMT (19), improvements in neuronal connectivity and changes in the gray and white matter regions of various brain areas are just some of the positive results. DMT is also crucial towards the improvement of motor function and quality of life as well.

For Parkinson's disease, a trial done by Rocha *et al.* (20), used Argentine tango or mixed dance classes for 1 hour, once a week, over the span of 8 weeks. For those in the tango group, improvements in mobility, balance, and motor function were observed. These enhancements can be attributed to the incorporation of auditory cues while having to move to the rhythm of a song. This can stimulate movement timing, further benefitting motor performance and learning. On the other hand, the mixed dance group had success with the freezing of gait. Even though this was a relatively short trial, it shows just how effective DMT can be at a lower dosage.

In a review about DMT for MCI, Huang *et al.* (21), found that global cognitive function, memory, EFs, attention, language, and mental health all saw positive improvement following a DT program.

Particularly, older patients had the most improved global cognitive function, likely attributed to the process of engagement required within DMT. This involves the activation of various sensory channels and fine motor skills that can lead to long-lasting effects on global cognitive function. Additionally, the memorization that is involved with learning choreography in dance activates different somatosensory cognitive brain regions, therefore helping to improve memory formation and retention. EF is also benefitted through DMT as was seen in a 6-month aerobic dance intervention. This could have been due to structural changes the prefrontal cortex undergoes following DMT, as seen though greater gray matter volume and activation in these regions.

DANCE MOVEMENT THERAPY FOR MS

Various physical improvements have resulted from DMT interventions for individuals with MS. A systematic review by Davis *et al.* (12) investigated 13 studies that varied in the kind of DMT intervention. These types ranged from targeted ballet training, salsa, ballroom, all the way to creative dance practice. The interventions were feasible and well-tolerated, typically conducted twice a week, 1 hour sessions, over the total course of 4-12 weeks. Despite the varied intervention styles, 6 studies noted improved balance after the trial. Tests such as the Mini-Balance Evaluation System, Berg Balance Scale, and Dynamic Gait Index were all used, with higher scores following the intervention. For gait, four studies evaluated changes and saw improvements in gait by using the 12-item Multiple Sclerosis Walking Scale and the Timed 25-Foot Walk test. When it comes to gait parameters specifically, there were significant improvements in the smoothness of speed, step length, and cadence. There were not many statistically significant improvements in walking endurance following the interventions, assessed by the 6-Minute Walk Test.

There were also some improvements noted with functional mobility, extremity functions, and reduced ataxia. As for functional mobility, multiple interventions led to higher Timed Up and Go scores, a test that indicates improved functional mobility. Several studies reported upper-extremity function improvements that

were assessed by the 9-Hole Peg Test. Along with this, one of the trials noticed additional reductions in extremity ataxia, showing smoother movement. While this review highlights the limitation that many of these studies were pilot with small sample sizes, study findings still demonstrate that DMT may result in improved balance, gait, functional mobility, extremity functions, and reduced ataxia.

Furthermore, when focusing on cognitive outcomes of DMT for MS, 'executive functions' is a key term that refers to multiple cognitive processes that are required when organizing one's thoughts in order to achieve a certain goal (22). This is an active process, not an automatic or instinctual process. The three main EFs are inhibition, working memory, and cognitive flexibility. They provide the basis for higher order controls such as reasoning or planning.

Inhibitory control allows for us to work against our impulses and instead choose how we want to react (22). Inhibitory control of attention, or selective attention, allows us to select what we want to focus on, shutting out other distractions. Inhibitory control over one's emotions and behavior, or self-control, is very important when resisting temptations or staying on task despite occasional impulsivity. Knowing the various aspects of inhibitory control, there are several tests used to evaluate them. The Stroop task, for example, may ask for someone to report the color of the ink of certain color words when they do not match (the word "green" written in red ink). This tests one's ability to inhibit our standard response to reading a word and instead focus on another factor: the color of the ink. Another test used is the Simon task, a test involving a button of Stimulus A on the left and a button for Stimulus B on the right. One stimulus appears at a time with a varied location, testing one's tendency to automatically choose the same side as the stimulus.

Working memory (WM) is the ability of holding onto a piece of information and working with it, whereas short-term or long-term memory serves for just holding information (22). An example of this could be remembering a password as you type it out. WM is essential when understanding written or spoken language, turning commands into actions, considering alternatives, and more. It is also crucial when analyzing connections between two separate ideas or objects. Additionally, WM works in relation to inhibitory control, and vice versa. When using inhibitory control, one actively uses WM as one must keep a goal of what to inhibit in their mind. When using working memory

to find connections between things, one actively uses inhibitory control to resist the urge to follow an old thought process. As far as how WM is tested, forward-digit span tests can be used with specific commands to activate the function. Rather than simply repeating the set of numbers heard, one might have to say them in numerical order. The Corsi-Block test is also used where a tester will touch blocks in a particular order and the patient must replicate this.

Finally, cognitive flexibility is our ability to respond to new situations and switch between tasks, building upon the previous two EFs. An example of this is that when we change perspectives, we inhibit previous perspectives and use our WM to look at things through a different view. If something unexpected occurs, cognitive flexibility allows for us to come up with new solutions and assess a new response mechanism. A very common test used to examine this EF is the Wisconsin Card Sorting Task. A patient must sort cards based on the given feedback and be able to switch between the sorting criterion (e.g., color, number). Other tests will also evaluate task-switching between two tasks. An example could be deciding whether a letter is a vowel or consonant, and whether a number is odd or even.

Given that EFs can be highly impaired with MS, some studies have included EF measures when investigating the effects of DMT on individuals with MS. Although this collection of literature is limited, the results show significant improvements in EF standardized testing scores that assess the most affected EFs: working memory, inhibition, and cognitive flexibility. The following four studies include an emphasis in exploring EF outcomes in MS, differing in their study design, type of dance styles, and EF evaluation methods (Table 1).

Ballroom pilot feasibility study for persons with MS

Ng *et al.* (23) performed a pilot feasibility study with 7 participants with MS that went through a ballroom dance program. There were an additional 6 MS patients that served as the control group, undergoing the same tests as the experimental group but without participating in the dance program. The experimental group attended two one-hour sessions per week over the course of 6 weeks. The dance sessions involved multiple ballroom dance variations: rumba, waltz, foxtrot, and push-pull. Each individual style is relatively similar but may vary in tempo, step pattern, and types of movements. As the program proceeded, the movement patterns became more complex, the tempo became faster, and there were shorter break times. The participants were evaluated

Table 1. Summarized Information for 4 Highlighted Studies About Dance Movement Therapy (DMT) for Executive Function (EF) in Multiple Sclerosis (MS)

Studies	Sample Size	Therapy Duration	Dance Style	EF Tests	Outcome
Ng <i>et al.</i> (23)	7 participants 6 control	2× 1 hr sessions/wk for 6 weeks	Ballroom dance variations	PASAT	PASAT improved from 49 to 55
Van Geel <i>et al.</i> (24)	7 dance participants 10 art participants	2× 90 min sessions/wk for 10 weeks	Unspecified–3 choreographies of varying difficulty and EF target	- PASAT - SDMT - Dual Task Tests	- PASAT improved from 49 to 55 - SDMT proved to be insignificant - Dual tasks showed significant improvement
Adamová <i>et al.</i> (25)	18 participants 18 control	2× 55min sessions/wk for 12 weeks	Rock and roll & Ballroom/ Latin	- SDMT - TMT-A - TMT-B	- SDMT improved from 61.75 to 68.88 - TMT-A decreased by 1 sec - TMT-B decreased by 13 sec
Trinchillo <i>et al.</i> (26)	7 participants	1× 1hr session/wk for 20 weeks	Tango	MSNQ	MSNQ improved from 21.28 to 17.71

This table compiles the key information—sample size, duration, dance style, EF test, and outcome—for 4 studies highlighted in the investigation of DMT as a means of mitigating EF impairment in individuals with MS. In this table the following EF tests are included: Paced Auditory Serial Addition Test (PASAT), Symbol Digits Modalities Test (SDMT), Dual Task tests, Trail Making Test A, B (TMT-A, B), and MS Neuropsychological Screening Questionnaire (MSNQ). PASAT assesses working memory (WM), SDMT assesses WM and processing speed, TMT-A, B assesses processing speed and cognitive flexibility respectively, and MSNQ evaluates cognitive impairment. Improvement in these tests signal improved executive functioning in the EF area in which the test evaluates.

with various questionnaires, clinical/functional outcome measures, and heart rate measures. For EF assessment, the Paced Auditory Serial Addition Test (PASAT) was used: the test involves the addition of consecutive single digits at a set rate, evaluating one's WM. The median scores improved from 49 to 55 post-intervention, indicating improved executive functioning which contributed to an improved MS Functional Composite Score.

Multimodal dance and art intervention pilot-trial for persons with MS

Van Geel *et al.* (24) set up a controlled pilot-trial with 17 MS participants to investigate the effects of a 10-week multimodal dance and art intervention. For the dance group (7 participants), 90 minute sessions were held twice a week where the participants learned 3 routines. The first routine was slower and included WM, the second routine consisted of synchronous movements and included inhibition and WM, and the third routine had a higher rhythm that included dual tasking. EFs were evaluated using the PASAT and the symbol digits modalities test (SDMT), a test where participants must match a symbol to its corresponding

number as quickly as possible. Dual tasks were also assessed by having participants walk with a cup of water in combination with a phonetic word list task and a subtraction task. Cognitive performance was determined by the number of correct answers. The median scores of the PASAT showed significant improvements, from 49 to 55, consistent with Ng *et al.*'s (23) study. Executive cognitive performance during dual tasking also improved significantly. The SDMT scores were not significantly different between the dance and control groups.

Impact of dance classes on motor and cognitive functions in persons with MS

Adamová *et al.* (25) conducted a randomized controlled trial with 36 RRMS patients (18 experimental and 18 control) with two 55 minute dance classes per week for 12 weeks total. On Tuesdays, patients had a rock and roll class that taught basic skills of rock and roll. The participants learned five routines of varying duration and difficulty as they gained more experience. On Thursdays, sports dance classes were held to teach ballroom and Latin American dance basics. The tempo of the music, traditionally faster for these styles, was

slowed down during the initial learning process. The main tests used to evaluate cognitive function were the SDMT and Trail Making Test A, B (TMT-A, B), where part A involves connecting a trail of numbers in ascending order and part B involves connecting a trail of numbers and letters in an alternating pattern. For TMT-A, there was a mean decrease of about 1 second, and a mean decrease of about 13 seconds for TMT-B by the end of the intervention. The improvement in TMT-B exhibits an improvement in cognitive flexibility, the targeted EF of this test. There was also significant improvement in SDMT scores, 61.75 to 68.88, signifying better performance with processing speed and WM.

Tango intervention study for persons with MS

Trinchillo *et al.* (26) explored the benefits of a tango dance therapy intervention on 7 middle-aged MS participants over the course of 20 weeks. The classes lasted for 1 hour per week where they would dance with a partner, and were led by a professional tango instructor. As far as the class structure, it began with stretching, followed by new material alone, and practice with their partners. Participants were provided with additional videos and music to practice the choreography on their own time. Cognitive function was assessed by the MS Neuropsychological Screening Questionnaire (MSNQ), scored 0-60 with higher scores indicating higher cognitive impairment. Improvements were noted through the reduction of scores from 21.28 to 17.71 post-intervention, pointing towards better executive functioning. Since this was evaluated through potentially subjective questionnaires, this does pose a limitation to this study.

CONCLUSION

In summary, the purpose of this review was to use the current available data of DMT interventions as a non-pharmacological form of treatment in improving motor functions and EFs in individuals with MS. This review sought to identify the limitations amongst current studies while providing suggestions for future research in using dance as a rehabilitation tool for both physical and cognitive impairment in those with MS.

When analyzing the four DMT-based interventions, there is some overlap and distinction between how EFs were examined in each study. Despite the varying styles of dance, program lengths, and experimental designs, the results show promising support towards

DMT as a means of improving EFs for those with MS. Van Geel *et al.*'s (24) study was the only out of the four to integrate various EF components in each of the pieces of choreography taught to the participants. These were also progressively challenging as each routine built upon the previous EF, from WM all the way to dual-tasking. This strategy of gradually targeting the various EFs could have contributed to the significantly improved executive performance in the dual tasks. Ng *et al.* (23) and Van Geel *et al.* (24) both used the PASAT as a measure of WM performance, surprisingly showing the same score improvements from 49 to 55. Even though these trials involved different dance-intervention styles, the consistency seen between their results can point towards DMT having positive effects on WM. This can be attributed to how participants had to juggle learning the choreography and applying it to varying rhythms when connecting the movements with music.

Adamová *et al.*'s (25) study provided more evidence toward improvements of EFs other than mainly WM. Unique to this study, TMT-A/B were used to test processing speed (A) and cognitive flexibility (B). While there was only a 1 second improvement in TMT-A, TMT-B demonstrated a 13 second improvement. Part B delves into one's ability to shift between focusing on two mental sets, letters and numbers, crucial to cognitive flexibility. SDMT results also showed improvements in processing speed. This particular study did have a larger sample size and most validated evidence towards DMT leading to cognitive benefits in comparison to some of the other smaller, pilot studies.

Unlike the other three studies, Trinchillo *et al.* (26) did not use the standard tests to evaluate EFs such as the PASAT or SDMT. Instead, this study utilized the MSNQ, a self-reporting tool that can be subjective. The MSNQ can be influenced by mood and can be easily manipulated in terms of accuracy. Even though participants reported improved cognition after the intervention, the subjective nature and small sample size of this study pose some limitations on these findings. It is difficult to differentiate between true improvements in EF versus better psychological well-being.

In summary, the studies that incorporated standardized measures (PASAT, SDMT, TMT-A/B) can provide more objective results that exclude potential biases. Studies like Van Geel *et al.*'s (24), that deliberately included EFs into the structure of the intervention also proved to be quite effective in seeing greater improvement. While all four studies pointed towards

the benefits of DMT on EFs, the study design, type of intervention, and measures used for testing ultimately could impact the strength of the findings.

For future studies in this area of research, follow-up assessments and larger, well-rounded sample sizes should be implemented. None of the four reviewed studies included a follow-up evaluation of the progression in the improvements observed after the intervention; this leaves the question of whether the executive gains could last over time or if they would need to be supplemented with further dance therapy sessions. Additionally, future studies could implement neuroimaging techniques into their testing measure to see the neural mechanisms powering the observed improvements in EFs. Additionally, small sample sizes are often a limitation in patient studies (27): there were many pilot studies, time-commitment issues, lack of people wanting to participate, and so on. However, these results can only be fully supported and used for future treatment strategy if there is more data to support it. With a larger collection of data, researchers can determine the structure, length, and intensity that supports the best outcomes. This can even lead to the possibility of testing DMT along with other pharmacological treatments to see the results with combined treatment. With the clarification of these parameters, researchers could develop accessible, personalized, and effective combined intervention methods to improve executive functioning in individuals with MS.

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CONFLICT OF INTERESTS

The author declares that there are no conflicts of interest related to this work.

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