Narrative Review Article

Dancing for Dopamine: A Review on the Efficacy of Dance in the Treatment of Parkinson's Disease

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ABSTRACT

Parkinson's disease (PD) is the second most common neurodegenerative disease after Alzheimer's in the United States. It is a progressive movement disorder that affects the substantia nigra, an area of the brain containing neurons that are responsible for producing dopamine. Symptoms of PD include tremors, rigidity, bradykinesia, cognitive impairments, and mental challenges. While there is currently no cure for PD, there are several pharmacological treatments that aim to alleviate the symptoms. These treatments, however, often cannot address the full breadth of the complex disease. As a result, increasing research has been conducted on several non-pharmacological interventions, including music therapy, community-based therapy, and exercise. These modalities have been shown to improve motor and non-motor symptoms and slow disease progression. Dance has emerged as a promising non-pharmacological intervention for PD. Several studies suggest that dance may be more beneficial to people with PD than music therapy, community-based therapy, and exercise alone. Dance synergistically combines music, community, and exercise, which may explain why dance is such an effective treatment.

Keywords: Parkinson's Disease; Dance; Non-pharmacological Treatment; Music; Community; Exercise

INTRODUCTION

Parkinson's disease (PD) is a neurodegenerative movement disorder characterized by progressive loss of motor and non-motor functions. The primary motor symptoms in PD include hand and leg tremors, rigidity, and bradykinesia. Non-motor symptoms can include cognitive impairment, sleep-wake cycle disturbances, and mood disorders. In the United States, approximately 500,000 individuals are diagnosed with PD, but it is estimated that undiagnosed or misdiagnosed patients bring this number to nearly one million. Risk factors for PD include age, environmental exposure to toxins, and heredity (1).

Clinical diagnosis of PD requires the presence of bradykinesia and at least one other cardinal motor feature, such as rigidity or resting tremor. However, people often develop PD years before they begin to exhibit motor symptoms. The preclinical phase of the disease is marked by symptoms like depression, hyposmia, and sleep disorders. The clinical phase begins when motor symptoms become apparent. These symptoms progress gradually, often beginning by only affecting one side of the body.

Due to the difficulty of early diagnosis, current research is focused on identifying predictive factors and biomarkers to identify individuals at risk for the development of PD. The presence of idiopathic rapid eye movement (REM) sleep behavior disorder (RBD) is currently the strongest predictive factor for PD (2). while possible biomarkers include increased levels of uric acid and alterations of the gut microbiota (3, 4).

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Further research is necessary to better understand the features of preclinical PD.

Individuals with PD also experience an accumulation of the protein α-synuclein in the brain. Research suggests that harmful accumulation of α-synuclein can lead to disruptions in normal cellular functions, triggering neuronal death (5, 6). While there is a familial form of PD where a genetic mutation causes α-synuclein to misfold, most people with PD do not have mutations in α-synuclein (7, 8). Regardless, almost every case of PD involves the buildup of α-synuclein, which forms aggregates. These protein aggregates combine to form fibrils, which then form Lewy bodies, a prominent pathological feature of PD (6, 7).

PD affects the substantia nigra, a part of the midbrain that is critical for motor control. The substantia nigra contains neurons that produce dopamine, a neurotransmitter responsible for generating smooth, purposeful movements. By the time of diagnosis, most people with PD have already lost 60-80% of their dopaminergic neurons (1, 9). This loss underscores the importance of early diagnosis and provides a potential pathway for treatment. The most common is levodopa (L-DOPA), a dopamine precursor that can cross the blood-brain barrier and is used to restore dopamine levels in the brain. L-DOPA is often used along with carbidopa, a decarboxylase inhibitor that prevents the breakdown of levodopa until it successfully crosses the blood-brain barrier. After several years of treatment with L-DOPA, however, individuals may experience levodopa-induced dyskinesia, a side effect characterized by jerky, involuntary movements of the body (6). Levodopa treatment is often supplemented with catechol-O-methyltransferase (COMT) inhibitors or monoamine oxidase type B (MAOB) inhibitors, which help limit levodopa degradation.

While these treatments are effective in relieving some of the symptoms of PD, they cannot often alleviate all motor and cognitive aspects of the disease, failing to slow the progression of PD (6). Researchers have turned to investigating the benefits of non-pharmacological interventions to improve quality of life and address many of the symptoms medication alone cannot fully treat. A recent Cochrane review on physical exercise for people with PD found that dance has the most beneficial effect on severity of motor signs (10). This paper will include an overview and analysis of the most common non-pharmacological approaches to PD, including music therapy, community-based therapy, and exercise. It will then explore dance as one of the most effective treatments for PD, due to its ability to uniquely combine music, community, and exercise. This review proposes that dance may be the most effective treatment due to the synergistic effect of these three interventions.

NON-PHARMACOLOGICAL INTERVENTIONS FOR PARKINSON'S DISEASE

There are a variety of non-pharmacological treatments used for PD. These interventions range from tai chi and boxing classes to therapeutic singing. Each of these interventions affects different aspects of the disease. Tai chi has been proven to improve postural stability (11), boxing improves balance (12), and music therapy can improve gait characteristics, mood, depressive syndromes, and memory (13). Studies have been conducted to compare the efficacies of various non-pharmacological treatments, and many times, dance has been shown to have the most benefits. As a combination of multiple different non-pharmacological therapies, dance incorporates many important aspects that contribute to its high efficacy.

Music Therapy as a Treatment for Parkinson's Disease

Recently, scientists have begun studying music therapy as a potential treatment for PD. Music therapy is defined as the use of music and sounds to develop both physical and mental well-being in a patient. It has been shown that musical rhythms can activate motor neurons, stimulating muscle contractions and body movements that synchronize with the rhythm (14). For people with neurological disorders like PD, music therapy can be an effective non-pharmacological form of rehabilitation. Common symptoms of PD, such as slower gait, loss of rhythm, and trunk instability, have been shown to improve with music therapy (15). Music also has positive benefits on mood and quality of life in people with PD.

Research has indicated that music therapy can be used to improve motor function, balance, and gait in PD patients. A study of PD subjects demonstrated that playing music during a 10m straight walking task significantly improves gait speed, acceleration, cadence, and step length, revealing the potential of music therapy as a simple method for relieving gait disturbance in everyday life (16). In another study, it was found that home-based rhythmic auditory stimulation (RAS) can significantly reduce the number of falls in PD patients, with the greatest improvements seen during the first 8

weeks (17). These two studies offer simple interventions that can have profound effects on gait and falls.

Using the Unified Parkinson's Disease Rating Scale (UPDRS), a common scale used in the research of PD to quantify the severity or progression of the disease, Pacchetti *et al*. found that combining music therapy with physical therapy significantly affected bradykinesia in people with PD (18). This study demonstrates that music has a definite effect on motor symptoms and highlights the additional benefits of music therapy when combined with physical therapy (Table 1).

Singing has also been shown to have benefits on gait

Table 1. Summary of Different Interventions and Their Effects on Parkinson's Disease

Reference	Type of Intervention	Results	
		Motor	Non-motor
16	Music	Significant improvement in acceleration, gait speed, cadence, step length. Immediately improved gait disturbance	
21	Music, community		Participants appreciated fellowship, found intervention was beneficial, fun, and engaging
29	Community		Cognitive behavioral group therapy led to significant stress reduction ($p<0.05$) and improvement in social skills ($p<0.05$)
30	Exercise, community	Significant improvement to 6-minute Walk test, grip strength	
18	Music, physical therapy	Significant UPDRS improvements to bradykinesia, activities of daily living, rigidity	Changes on Happiness Measure confirmed significant effect on emotional functions, quality of life
54	Music, physical therapy	Significant improvement to static and dynamic balance	Higher outcome scores concerning mood and quality of life
34	Exercise	Level 1 evidence aerobic exercise improves VO_2max and attenuates motor symptoms	Conflicting results on non-motor symptoms
37	Exercise	Aerobic exercise attenuates off-state motor signs (UPDRS motor improved while minimising confounding effects of medication)	
10	Dance, exercise	Dance had the largest beneficial effect on severity of motor signs of the different exercises in 154 RCTs	Dance may have a small beneficial effect of quality of life
48	Dance	Three year longitudinal data showed there was no daily motor rate of decline (no progression of motor impairment)	No significant decline in daily living, motor experiences of daily living, motor complications
45	Dance	Significantly improved movement, balance and gait	Significantly improved abstract reasoning, inhibitory control, depressive symptoms, quality of life
41	Dance	Gait improvements sustained after class	Supportive community and teachers, getting in touch with previous treasured life experiences
49	Dance		Significantly improved cognitive skills, psychologic symptoms, quality of life

and speech in PD patients. Harrison *et al*. found that singing, either out loud or internally, can improve gait speed and stride length in individuals with PD (19). The study showed that matching cadence to one's voice can improve gait and reduce gait variability in older adults and adults with PD. Additionally, a systematic review observed that of 7 studies investigating the impact of singing on speech, 5 of them found partial evidence of benefit (20). Stegemöller *et al*. found that an individual singing program significantly improved maximum phonation time (a measurement of how long someone can hold a vowel sound in one breath), Geriatric Depression Scale ratings, voice-related quality of life, and Voice Handicap Index scores (21). These three studies use an intervention that can be easily accessed and implemented, but they do not examine the sustained benefit of singing in PD patients. Future studies should investigate the durability and long-term effects of singing therapy.

Playing musical instruments may also be a form of a music-based intervention that can alleviate the symptoms of PD, but there is limited research investigating the effects of instrumental performance on motor function. Some preliminary studies suggest that singing or playing a wind instrument could potentially improve respiratory function in PD patients or people with other neurologic disorders (20, 22). Other studies that explore the benefits of playing percussion instruments found that percussion playing, when combined with other interventions, can improve bradykinesia (18). However, not all studies have exclusively positive results. Bugos *et al*. found that intensive piano training improved executive function, but it decreased quality of life due to an increase in fatigue (23). As research on music therapy continues, it is important that any negative effects are clearly reported. This will allow scientists to properly address possible flaws in the treatment plan and reduce harm to patients.

Many of the studies that explore the motor effects of music therapy primarily focus on gait, due to the rhythmic nature of music. This focus has resulted in fewer established benefits of music on other motor symptoms of PD. Other limitations of these studies include small sample size and lack of controls, since they are pilot or feasibility studies.

Community-based Interventions in Parkinson's Disease

Individuals with PD often experience social withdrawal and loneliness, which can disrupt social roles and activities of daily living (24). Though the biological mechanisms connecting social isolation and PD are unclear, this relationship is important to study because social withdrawal can adversely affect quality of life, perhaps even more than the motor symptoms of PD. In a review of 58 studies, it was found that people with PD reduced their social activities, either voluntarily or involuntarily, and the social withdrawal that resulted from this was associated with physical, cognitive, and psychiatric problems (25). Additionally, data suggest that increased social isolation, especially decreased friend and family visits, is associated with a higher risk for the development of PD (26). While the mechanisms of this relationship have not yet been determined, there are several possible explanations. Social disconnection has been linked to mitochondrial dysfunction and oxidative stress, two critical characteristics of PD pathology. Social isolation can also cause changes in social inequality, preventing PD patients from seeking out and receiving the care and social support they need.

It has been demonstrated that PD impacts the quality of relationships and increases levels of loneliness and social isolation, resulting in a decline in quality of life (27). Community-based interventions for people with PD are a promising way to mitigate loneliness and social isolation. These interventions can range from in-person boxing classes to online peer support groups. Especially since the COVID-19 pandemic, more studies have examined the benefits of technology and digital communities for PD. A study by Moya-Galé *et al*. analyzed the transcripts of video-recorded focus groups and found that group rehabilitation is an effective way to facilitate social connections (28). Use of digital technologies to create online peer support groups should be further explored, as it may contribute to increased social interaction and improved quality of life.

Group therapy sessions are an example of a community-based intervention that involves physical interactions with others. Cognitive behavioral therapy (CBT) is a group or individual treatment that can help PD patients cope with depression and anxiety related to the disease. A study conducted by Hadinia *et al*. examined the effect of CBT and found that CBT effectively improves quality of life by improving emotional well-being and significantly decreasing stress (29).

In a study that focused on a group exercise class, States *et al*. found that participants' strength and mobility increased (30). In some cases, those who participated in a long-term program saw increased benefits. The study suggests that group exercise programs are a safe and feasible way to prevent the worsening of PD

symptoms, and the combination of community-based therapy and exercise might help sustain improvement. Another example of community-based interventions for PD is group therapeutic singing. A study that examined a group singing intervention (GSI) in people with PD found the GSI to be a promising community-based intervention (21). Participants reported that the therapy was fun, engaging, and beneficial, and they enjoyed the company of other individuals with PD. These two studies suggest that community-based therapies are especially beneficial when combined with exercise or music-based therapy (Table 1).

The Role of Exercise in Treating Parkinson's Disease

Exercise is a therapy commonly used to improve well-being in all adults, not just those with PD. Research has proven exercise to be effective in maintaining good cardiovascular and bone health, helping to prevent diseases such as cardiovascular disease and osteoporosis. Studies also suggest that individuals who are more physically active may be at a lower risk of developing PD (31, 32). This is possibly because those who exercise regularly do not frequently experience the prodromal symptoms of PD (depression, constipation, bodily pain). Because the connection between physical activity and the prevention of PD is still unclear, further research will have to be conducted to accurately determine the relationship.

For those who have PD, evidence shows that exercise is an effective intervention, and it can significantly improve overall physical fitness and motor symptoms of the disease (33). 10 different randomized trials investigated the impacts of aerobic exercise on physical fitness in individuals with PD (34). While the trials differed in length, intensity, and frequency of exercise, they all confirm that exercise improves PD symptoms and slows the progression of the disease. One study found that aerobic exercise improves VO_2max performance and can even improve quality of life (35). Evidence suggests that aerobic exercise can also reduce the early and intermediate stages of motor PD symptoms. Therefore, those who participate in aerobic exercise programs often see reduction of tremors and bradykinesia, and an improvement in balance and gait.

An example of an exercise program developed for people with PD is the Beat Parkinson's Today exercise program. The program uses high intensity interval training and boxing, both of which have been proven to be beneficial for PD patients. During the COVID-19 pandemic, small online classes were used to simulate community. In a study conducted on participants of the Beat Parkinson's Today program, participants were able to reach and maintain their target heart rate, and they experienced no significant changes in motor impairment (36).

In the Park-in-Shape trial conducted by van der Kolk *et al*., 130 PD patients were randomly assigned to either an aerobic exercise intervention group or a stretching control group (37). The study found that aerobic exercise done at home can attenuate off-state (≥ 12 hours after last dopaminergic medication) motor symptoms in people with PD (Table 1). In a follow-up study to the Park-in-Shape trial, a subset of Park-in-Shape participants underwent resting-state functional and structural magnetic resonance imaging (MRI) both before and after the 6 month treatment program, which consisted of either aerobic exercise or stretching (38). The study found that aerobic exercise resulted in greater connectivity of the anterior putamen with the sensorimotor cortex, and in the right frontoparietal network. Additionally, another trial, the SPARX trial, found that high-intensity treadmill exercise can potentially be used as a non-pharmacological intervention for PD (39). After 6 months of intervention, the UPDRS motor score of each participant was compared to their score before the trial. Compared to a moderate-intensity treadmill exercise program, the high-intensity group experienced greater benefits with regards to motor symptoms.

Both the Park-in-Shape and SPARX trials are large and well-conducted; however, their focus is on motor benefits, and not non-motor benefits. This lack of non-motor effect may be a limitation of isolated exercise treatment for PD. The goal of synthesizing available studies is to develop an effective treatment plan; however, it is often difficult to draw conclusions due to the heterogeneity of studies. Studies vary widely in treatment variables such as intensity, duration of classes, duration of treatment, and type of exercise. They also measure different outcomes, even when assessing the same variables. This makes it challenging to formulate a treatment plan, and future studies should consider standardizing their protocols.

DANCE AS A COMBINATION OF MUSIC, COMMUNITY, AND EXERCISE IN THE TREATMENT OF PARKINSON'S DISEASE

Dance is a promising non-pharmacological intervention for PD because of its ability to combine

music therapy, community building, and physical activity into one treatment. A major component of dance is exercise, and, in general, most forms of exercise are beneficial for people with PD. However, increasing evidence suggests that dance is more effective than other types of exercise. In the Cochrane Database of Systematic Reviews, Ernst *et al*. compared several types of exercise and stated that dance was the highest-ranked intervention with a beneficial effect on the severity of motor signs (Table 1) (10). Additionally, a study conducted by Alvarez-Bueno *et al*. found that interventions that involved more complex and demanding activities, such as dance, were the most effective form of exercise treatment for individuals with PD (40). Combined, these findings prompt the question of what sets dance apart from other forms of exercise that have been shown to improve motor function in PD patients, such as resistance training, gait training, and endurance training.

One potential explanation is that while dance is an effective form of exercise, it is also a multisensory integration of several other therapeutic components, such as music and community intervention. States *et al*., Stegemöller *et al*., and Pacchetti *et al*. have shown that combining two of the three components of dance is more effective than any individual component in isolation (30, 21, 18). It is unclear if the same effect would be achieved by sequential performance of the individual therapies. Understanding that music, community, and exercise are each individually beneficial to people with PD, it can be hypothesized that dance, as a synergistic combination of the three interventions, is more effective than a therapy containing only one component.

In a study conducted by Jola *et al*., the helpful aspects of a dance class for people with PD were identified as music and rhythm, supportive and encouraging teachers, movements that exercise all parts of the body, explanations of the purpose of different routines, and getting in touch with previous treasured life experiences (41). These aspects are not seen in every exercise program and are unique to dance, providing a possible reason why dance therapy is more beneficial than other exercise treatments.

Another potential explanation for the enhanced benefits of dance classes is that individuals with PD often lose their internal cueing systems, causing a decline in their ability to perform rhythm-based tasks such as walking and speaking. Because dance classes consist of movements to the rhythm of the music, dance involves rhythmic motor training, which is an essential component of an effective PD therapy (42, 43). While many other physical activity interventions use music, exercises are seldom performed to the beat of the music. Using music to encourage and initiate movement in a welcoming environment seems to be a key factor that sets dance apart from other interventions.

Dance classes have proven to be successful in improving not only motor challenges, but also quality of life and non-motor symptoms. Several programs around the globe offer dance classes for individuals with PD. One such program is the *Dance for PD* program, a collaboration between the Mark Morris Dance Group and the Brooklyn Parkinson Group, which teaches mixed dance and has certified instructors in 30 countries. The class is offered weekly, and studies have demonstrated its ability to improve the quality of life of people with PD. Qualitative evidence suggests that after taking community-based dance classes, participants have a better sense of positive self-identity after a PD diagnosis, a better mood, and decreased feelings of isolation, in addition to enhanced motor ability (44).

Further evidence suggests that dance can be used to treat mood disturbances and internal negativity in individuals with PD. Studies show that dance can reduce depression in all adults (45, 46), and Fontanesi and DeSouza found that dance has the unique ability to improve wellbeing, body self-efficacy, and experience of beauty (47). Compared to a matched-intensity exercise session, just one *Dance for PD* class helped PD patients increase their body self-efficacy and experience of beauty. This is likely because in a dance class, adults with PD experience themselves as elegant and beautiful, and this feeling of beauty may contribute to beliefs of what the body is capable of doing.

While it has been demonstrated that *Dance for PD* classes can have positive benefits in the short term for individuals with PD, Bearss and DeSouza measured the effects of dance over an extended period of time.[48] They studied 16 participants of a weekly *Dance for PD* class at Canada's National Ballet School over three years and measured their UPDRS I, II, III, and IV after each class. The results of the study indicated that those who received long-term dance treatment experienced no motor decline, while those who did not experienced expected motor decline.

The majority of the benefits associated with dance are related to motor symptoms of PD, but it is also important to note that dance also affects non-motor symptoms. A study conducted by Kalyani *et al*. found that dance improves some cognitive skills,

psychological symptoms, and quality of life (49). These results are supported by Duarte *et al*. in their study investigating both the motor and non-motor effects of dance on people with PD (45). The study found that after 6 months of intervention, dance improved gait and balance, but it also improved depression, abstract reasoning, inhibitory control, conceptualization, and quality of life.

Social interactions and community building are also important aspects of dance classes. Factors such as the COVID-19 pandemic and the need to accommodate members of the PD community in rural or remote areas have prompted the expansion of digital dance classes. However, these classes have still managed to maintain close social communities through virtual coffee times after class and the creation of online forums for students. While online dance classes may not provide a physical community for participants to interact with, research shows that despite the lack of a physical community, participants still benefit from the class (50, 51). This evidence suggests that there is flexibility in the process of creating an effective dance class; classes can be online or in-person, and, as further studies indicate, they can involve a diverse range of dance styles.

After confirming dance's potential to improve motor symptoms, Carapellotti *et al*. investigated the effects of several different dance styles, such as ballet, tango, and Irish set dancing, and each style demonstrated equal levels of benefit to people with PD (52). The benefits of each dance style were also found to be potentially greater than those of other forms of exercise interventions. While the style of dance taught in dance classes does not matter, there are many aspects of dance classes for PD patients that should be included to create an effective class. First, classes should include rhythmic music in two or four beats. Movements should be performed at the same tempo as the music. Evidence suggests that dancing to binary (two-beat) and quaternary (four-beat) rhythms can improve balance and freezing of gait (53). Classes should also involve rigorous exercises, as aerobic exercise is the most effective for people with PD. Additionally, participants should have classmates who are also living with PD. Research has shown that in group settings, it is helpful for individuals with PD to be in the company of other people with PD, as it allows them to build deeper social connections (28). Lastly, participants should be referred to as "dancers" (47). Promoting participants' self-identities as dancers, rather than patients, can affirm their identity of beauty and grace, and it can even inspire participants to move beyond their preconceived limits. While these criteria may not be met in every dance class, evidence suggests that these aspects should be present to achieve the most positive outcomes. Combining rhythmic cueing, meaningful social interactions, and aerobic exercise into one therapy creates a PD intervention that is uniquely beneficial to PD patients.

CONCLUSION

As the presence of PD grows among the aging population, there is an increasing need to understand effective non-pharmacological interventions that are easily accessible and can be employed quickly. A wide range of such interventions have been researched, and many of them have been proven to improve motor and non-motor symptoms, slowing the progression of PD.

Music therapy, community-based interventions, and exercise are all promising and proven non-pharmacological interventions for the treatment of PD. Music-based interventions such as rhythmic auditory stimulation (RAS), singing therapy, and even playing musical instruments have been shown to improve gait, voice impairments, and risk of falling. Community-based therapy and increased social interactions combat loneliness and social isolation in people with PD. These treatments also equip PD patients with the skills to manage and cope with their condition, providing them with a supportive community of other adults with PD. Lastly, exercise, especially aerobic exercise, has proven to be an effective PD intervention because of its ability to improve strength and mobility and alter brain connections.

Dance, a synergistic combination of music, community, and exercise, has been proven to be an effective non-pharmacological intervention for PD. In fact, evidence suggests that dance is more beneficial than any of the three components individually. Many past studies have examined the effects of dance classes on individuals with PD. These studies have highlighted several aspects of dance that are especially helpful. One important aspect of dance is performing aerobic exercises to binary or quaternary rhythms. Research has indicated that moving to the beat of two or four beat music can improve motor symptoms such as gait and balance. Another important aspect of dance is the supportive community the class fosters; putting PD patients in a class with others who share the same struggles allows participants to build new relationships and combat the social isolation many adults with PD

experience. Finally, in a dance class for people with PD, it is important to promote participants' self-identity as a dancer, rather than as a patient. Doing so will uplift participants, encouraging them to embrace their beauty and grace.

Accessibility to PD interventions remains a challenge, especially for individuals living in rural or remote areas. One solution to this problem is digital dance classes, which seem to be very effective despite the lack of physical community. Further research should develop new ways for dance to reach a larger PD audience but still retain the diverse benefits of a dance class.

As a combination of many different non-pharmacological therapies, dance has the unique ability to alleviate both motor and non-motor PD symptoms. Future studies should focus on the long-term effects of dance on individuals with PD and continue to investigate the aspects of dance that set it apart from other non-pharmacological options. Additionally, more work is needed to determine the biological mechanisms underlying the ability of dance to slow the progression of PD, potentially through randomized clinical trials with temporal MR imaging study endpoints. These imaging tools would also be used to uncover the effects of dance on neuroplasticity and its ability to slow the progression of PD. While dance has been shown to be both practical and effective in the treatment of PD, further research should establish an optimal treatment plan for dance therapy, including variables such as class length, intensity, music and dance style, and the duration of the intervention. Dance holds the potential to meaningfully transform the lives of individuals with Parkinson's disease.

CONFLICT OF INTERESTS

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

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