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The Effects of Mindfulness Meditation on Cognitive Memory and Concentration as Indicators for Neurodegenerative Diseases and Disorders

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ABSTRACT

Meditation has been shown to have properties of improving neurocognitive memory and attention. However, there has been little research on mindfulness meditation, which is the practice of paying attention to the present moment. This study aims to highlight mindfulness meditation and its effects on memory and concentration. It was hypothesized that if research participants undergo a 10-minute mindfulness meditation period, then there will be a statistically significant increase in their cognitive memory and concentration as measured by their scores on a pattern memorization test and a color-word association test. The study was conducted through adults who consented to participate. They were randomly assigned to a no mindfulness meditation control group or the mindfulness treatment group. Both experimental groups then took a word memorization test where the percentage of words they could memorize was collected and a color-word association test where the percentage of colors they could identify were collected. The treatment group engaged in a 10-minute guided mindfulness session and both groups took both tests again with their scores recorded a second time. Four one-way ANOVA tests were conducted, with the first and second comparing the before and after mindfulness meditation test scores on both tests of the mindfulness group ($p = 0.0247$ for the word test and $p = 0.0387$ for the color test) and the final two ANOVA tests comparing the no mindfulness and mindfulness meditation groups after the session ($p = 0.0346$ for the word test and $p = 0.0478$ for the color test). Mindfulness meditation was determined to have a significant increase in memory and concentration in this study, showing that mindfulness would also have positive impacts on neurodegenerative conditions. This is beneficial and it is hoped that mindfulness meditation would not only be implemented as a therapy for memory and concentration-affecting diseases like Alzheimer's Disease, but also for other neurodegenerative diseases and disorders.

Introduction

Neurodegenerative diseases and disorders affect over 150 million people, which is nearly one in six people worldwide. With time, this number will only continue to increase as the causes for many neurological conditions are still not yet known. Some of the conditions include Alzheimer's disease, Parkinson's disease, Huntington's disease, depression, bipolar disorder, OCD, and many more. The effects are quite well known in these conditions, however. Two common factors that are affected by neurological conditions are memory and concentration. Memory is a prevalent, vital function that every individual uses on a daily basis, and it often is significantly impacted when neurodegenerative diseases are present, with an example being Alzheimer's disease. The same goes for concentration, another important human function which is disrupted in disorders like depression and Obsessive Compulsive Disorder (OCD). As the rates of severeness and mortality due to these diseases and disorders increase, the need for trying to find preventions and therapies for them is highly needed.

Meditation in general is highly popular today. Many people have commercialized the beneficial effects of meditation, and it has been researched to a fair extent. However, many of its forms are present that the general

public does not know much about, with one being mindfulness-based interventions. Mindfulness-based interventions (MBIs), procedures involving the implementation of mindfulness, have already not been studied too much. What adds to this gap in knowledge is that out of the select studies that have researched MBIs, many of them only apply MBIs to a single neurodegenerative condition. Mindfulness implemented in meditation is one of the most prevalent ways to conduct MBIs. This paper serves as a primary research study in order to take a closer look into mindfulness meditation and its effects on memory and concentration, so that the effects can be associated with neurological conditions.

MBIs and meditation have been looked at before, especially in prominent neurodegenerative conditions like Alzheimer's disease and depression. However, one study has linked MBIs to bettering general cognitive decline in patients of old age. It was found that cognitive decline was statistically significantly reduced in these patients when they underwent an eight-week long mindfulness training program (Tran et al., 2023). The significance of this study not only furthers the connection between mindfulness and the common cognitive decline in people of old ages, but it connects mindfulness and all types of neurodegenerative conditions. Like this, memory and concentration should be studied in adults to further correlate MBIs and mindfulness meditation with many neurodegenerative diseases and disorders as well.

This study was conducted by the researcher because of her inspirations from many places. At a young age, she was introduced to spirituality through classical music and dance, where meditation sessions were conducted at the start of classes in order to promote better concentration and alertness during class. Additionally, she goes to mindfulness sessions that her school counselor often holds on school mornings which are extremely beneficial in recollecting more in exams and classwork later in the same day. Along with this, her passion for neuroscience, namely neurodegenerative diseases, further fuels her drive for doing more research correlating mindfulness meditation and neurodegenerative diseases and how mindfulness meditation can play a significant role in treating the diseases.

Mindfulness-Based Interventions on Depression

The effects of MBIs on the progression and treatment of depression alone are well-studied. It has been previously established that depression has been shown to have reduced when mindfulness therapy training is conducted and even people with major depressive episodes in clinics have been feeling alleviated of pressure and stress after the mindfulness training (Keng et al., 2022).

Table 1. This table by Keng et al. shows how many long mindfulness training sessions have been conducted in the past by other successful researchers. In every single previous study demonstrated in the table, the Mindfulness-Based Cognitive Therapy (MBCT) worked the same, if not better, than other therapies in bettering depression symptoms and severity. (Source: Keng et al., 2022)

Study	N	Type Participant	Mean Age	% Male	No. of Treatment Sessions	Control Group(s)	Main Outcome

2010	27	Depressed patients with a history of suicidal ideation or behavior	42	33	8 2-hr sessions	TAU (13)	MBCT + TAU > TAU: reduced depression severity, increased meta-awareness of & specificity of memory related to previous suicidal crisis
Williams et al., 2008	68	Patients with unipolar and bipolar disorders	NR	NR	8 2-hr sessions, 1 all-day session	WL (35)	MBCT > WL: reduced depressive symptoms in both subsamples & less increase in anxiety among bipolar patients
Bondolfi et al., 2010	60	Patients in remission from depression and with a history of 3 or more depressive episodes	47	28	8 2-hr sessions	TAU (29)	MBCT + TAU > TAU: prolonged time to relapse; Tx = TAU: rate of depressive relapse/recurrence
Godfrin & Heeringen, 2010	106	Recovered depressed patients with a history of 3 or more depressive episodes	46	19	8 2.75-hr sessions	TAU (54)	MBCT + TAU > TAU: reduced rate of depressive relapse/recurrence, depressive mood & quality of life
Piet et al., 2010	26	Patients with social phobia	22	30	8 2-hr sessions	GCBT (12)	MBCT = GCBT: reductions in symptoms of social phobia
Thompson et al., 2010	53	Patients with epilepsy and depressive symptoms	36	19	8 1-hr sessions	TAU (27)	MBCT > WL: reduction in depressive symptoms

In addition to this, mindfulness-based interventions have been almost better than antidepressants in treating depression (Komariah et al., 2022). In the study by Komariah et al., it was shown that quick and mindful self-awareness breathing helped calm depressed patients down and got them to relax for a while. The same

results were reviewed, and the review helped solidify the causation effect that MBIs can have very positive impacts on depression (Zollars et al., 2019).

Mindfulness-Based Interventions on Alzheimer's Disease

Many forms of MBIs have also been studied for Alzheimer's Disease. One such study investigated an ancient form of mindfulness, Kirtan Kriya meditation, in which a chant, normally the word "aum," is repeated continually for around 12 minutes and promotes deep self-thought and self-awareness while uttering the syllable (Khalsa, 2015). The review highlighted the high significance rate of past study's results. Linking MBIs and Alzheimer's disease has also been done in numerous primary research studies. One such study was performed by Innes et al. in 2018. This study showed that telomerase, an enzyme blood biomarker of Alzheimer's disease in which shortened lengths of telomerase are present, was increased in length in the Alzheimer's patients after self-aware meditation was conducted. The results of the study were statistically significant, and more studies followed suit. Another study involving MBIs more specifically with Alzheimer's disease was a study by Giulietti et al. in 2023. A mindfulness training program was implemented for patients in the early stages of Alzheimer's disease and showed significant results associated with Everyday Cognition Scales, which is a score of how well a patient is doing in terms of cognitive function (Giulietti et al., 2023).

Mindfulness-Based Interventions on Brain Development

Mindfulness-based interventions have also been shown to play a key role in the overall brain development of human beings. A study done by Lardone et al. in 2018 showed that theta bands, measures for brain activity in the hippocampus, was statistically significantly higher in people who engaged in mindfulness sessions as opposed to those who did not.

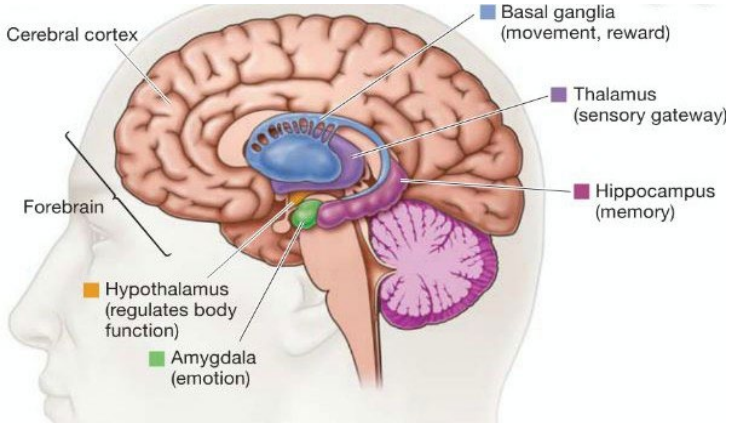

Figure 1. This figure depicts all the parts of the brain involved when mindfulness is undergone. First, the hippocampus, which is the primary component of the brain associated with memory, is affected and positively impacted. The forebrain and prefrontal cortex control concentration, and as shown in the image, these regions in the brain are also highly affected. Many other parts of the brain directly benefit from mindfulness therapies and sessions, as shown. To name an example, the Basal ganglia is also involved, and this is the primarily affected brain region in Parkinson's diseases, which shows how mindfulness and MBIs can be a good therapy for any disease. However, the need to study functions like memory and concentration which can be applied to all conditions is still eminent. (Source: Rodriguez, 2022)

Methods

This study aims to focus on how mindfulness meditation, a form of MBIs, could be used to improve memory and concentration levels in adults. In order to make a guided mindfulness meditation session to conduct, online mindfulness practice sessions were examined and a 10-minute excerpt was collected from the Headspace website. This was then used in the research study.

For the research study, adult human participants (n = 16) within the age range of 31 to 42 years old were randomly selected from the Dolley Madison Library in Fairfax, Virginia after giving their consent to partake in the study. This was done through a handwritten consent signature form. The study that followed was done in the library itself, which gave its permission for the study to be conducted in the facility. The participants were then split into a mindfulness meditation treatment group (n = 8) and a control group who did not receive the meditation treatment (n = 8). After taking around 10 minutes with the participants to settle and explain experimental procedures, both treatment groups took a word memory test and a color-word association test. The word memory test was a test in which a series of 10 common English words were flashed on a computer screen in front of all participants, with the words appearing for two seconds each. The subjects were then instructed to write as many words as they could remember and the percentage of words they were able to memorize was recorded. Following this test, the color-word test was held, where all the participants took an online test. In this test, a color was presented as a written word, but the actual color of the written word itself was a different color than the color that the written word indicated. The participants had to select the color that the written word was in, and the percentage of their correct answers were recorded. After taking these two tests, the meditation treatment group engaged in a 10-minute guided mindfulness meditation session, which was the excerpt of online mindfulness meditation as specified. During this session, the participants were guided to focus on themselves, each part of their body, and on the present moment. Around a minute afterward, both treatment groups took both the word memory test and the color-word association tests again, and the percentage scores were recorded again.

Table 2. Individual demographic data for all participating adults. The age range as specified was 31-42 years old, with the ratio of females to males being 10:6. All participants had at least one child, with 5 participants having more than one child. Neither name nor race was collected to ensure comfortableness and privacy for all participants. Participants 1-8 were the control group and did not engage in the mindfulness meditation session, and participants 9-16 were the mindfulness treatment group who did participate in the session. (Source: Mukund, 2024)

Person	Group	Age (years)	Gender	Children
1	No mindfulness	34	Female	1
2	No mindfulness	37	Female	2
3	No mindfulness	39	Male	1
4	No mindfulness	42	Female	1
5	No mindfulness	33	Female	1
6	No mindfulness	40	Male	2

7	No mindfulness	40	Male	3
8	No mindfulness	38	Female	1
9	Mindfulness	31	Female	1
10	Mindfulness	36	Male	1
11	Mindfulness	37	Male	1
12	Mindfulness	37	Female	2
13	Mindfulness	41	Female	2
14	Mindfulness	33	Male	1
15	Mindfulness	34	Female	1
16	Mindfulness	38	Female	1

Results and Discussion

Before and After Mindfulness Session Test Scores of Mindfulness Treatment Group.

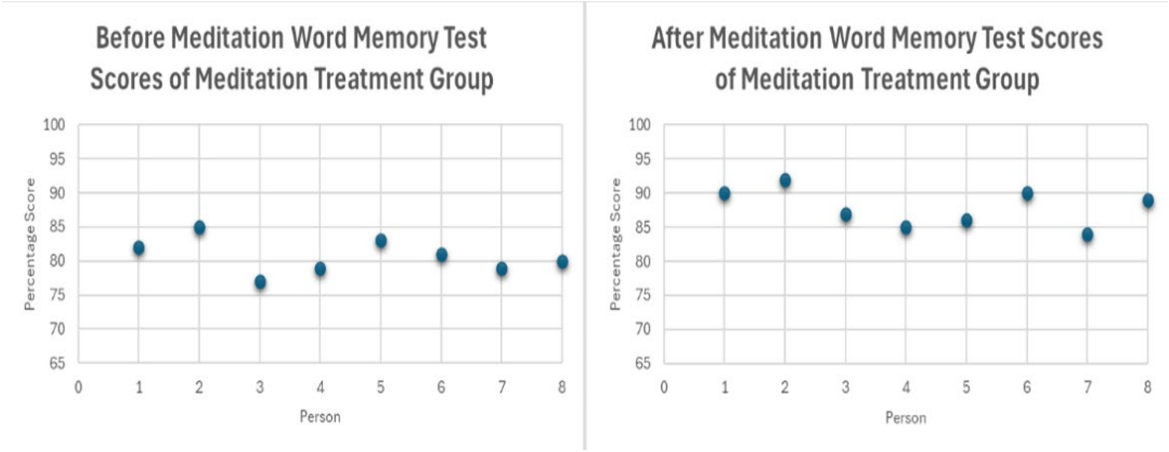

Figure 1 (left). The scores of the meditation group participants on the word memory test before the meditation treatment.
Figure 2 (right). The scores of the meditation group participants on the word memory test after the meditation treatment.

(Source: Mukund, 2024)

Figures 1 and 2 are scatterplots of the word memory test scores of the mindfulness treatment group before the 10-minute mindfulness session and the word memory test scores of the mindfulness treatment group after the mindfulness session, respectively. When looking at where the values tend in both graphs, it can be clearly seen that the values in Figure 1 tend to be lower than the values in Figure 2. This tendency was verified

by an ANOVA statistical test with an alpha level of 0.05. At this significance level, the ANOVA test outputted a p-value of $p = 0.0247$, meaning that $p < 0.05$. This result shows that there was a significant increase between the before and after meditation word memory test scores of the mindfulness treatment group.

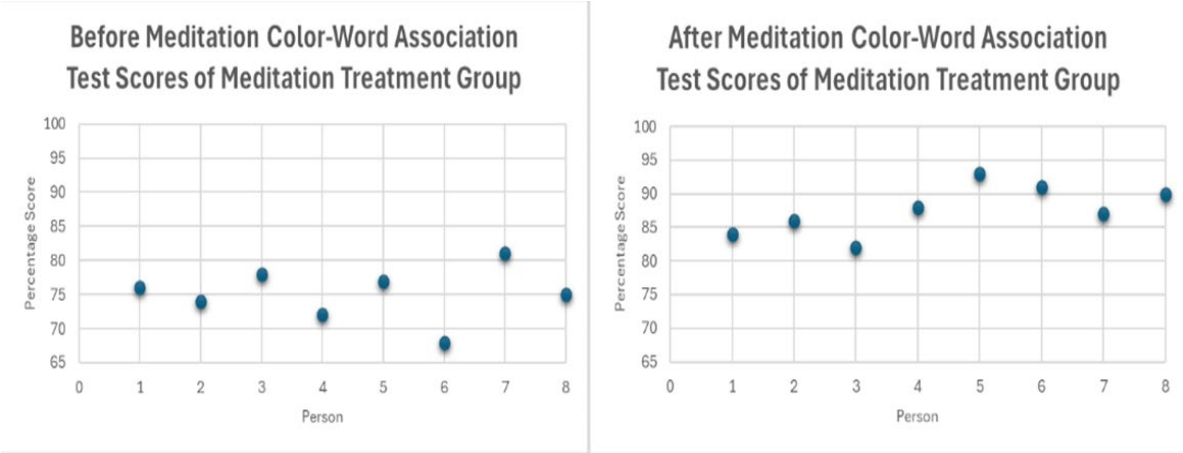

Figure 3 (left). The scores of the meditation group participants on the color-word association test before the meditation treatment.
Figure 4 (right). The scores of the meditation group participants on the color-word association test after the meditation treatment.

(Source: Mukund, 2024)

Figures 3 and 4 are scatterplots of the color-word association test scores of the mindfulness treatment group before the 10-minute mindfulness session and the color-word association test scores of the mindfulness treatment group after the mindfulness session, respectively. When looking at where the values tend in both graphs, it can be clearly seen that the values in Figure 3 tend to be lower than the values in Figure 4. This tendency was verified by an ANOVA statistical test again with an alpha level of 0.05. At this significance level, the ANOVA test outputted a p-value of $p = 0.0387$, meaning that $p < 0.05$. This result shows that there was a significant increase between the before and after meditation color-word association test scores of the mindfulness treatment group.

No Mindfulness Group and Mindfulness Group Test Scores After Meditation Session

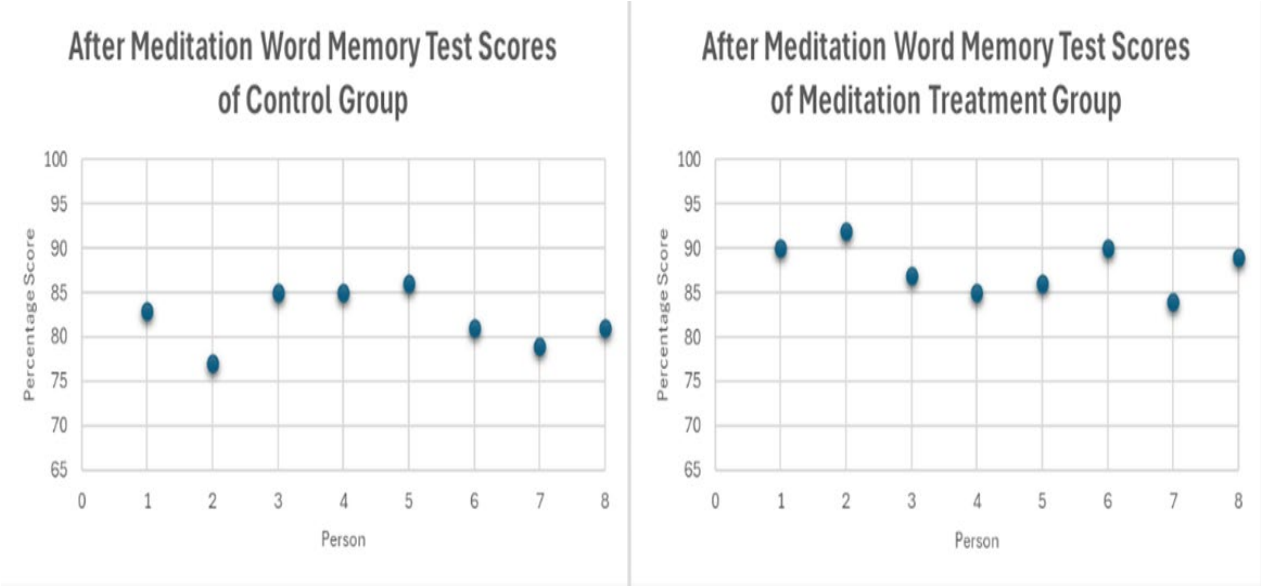

Figure 5 (left). The scores of the meditation group participants on the word memory test before the meditation treatment.
Figure 6 (right). The scores of the meditation group participants on the word memory test after the meditation treatment.

(Source: Mukund, 2024)

Figures 5 and 6 are scatterplots of the word memory test scores of the no mindfulness treatment group and the word memory test scores of the mindfulness treatment group, respectively. When looking at where the values tend in both graphs, it can be clearly seen that the values in Figure 5 tend to be lower than the values in Figure 6. This tendency was verified by another ANOVA statistical test with an alpha level of 0.05. At this significance level, the ANOVA test outputted a p-value of $p = 0.0346$, meaning that $p < 0.05$. This result shows that there was a significant increase in the word memory test scores between the no mindfulness meditation control group and the mindfulness meditation group after the mindfulness session was held with the mindfulness meditation group.

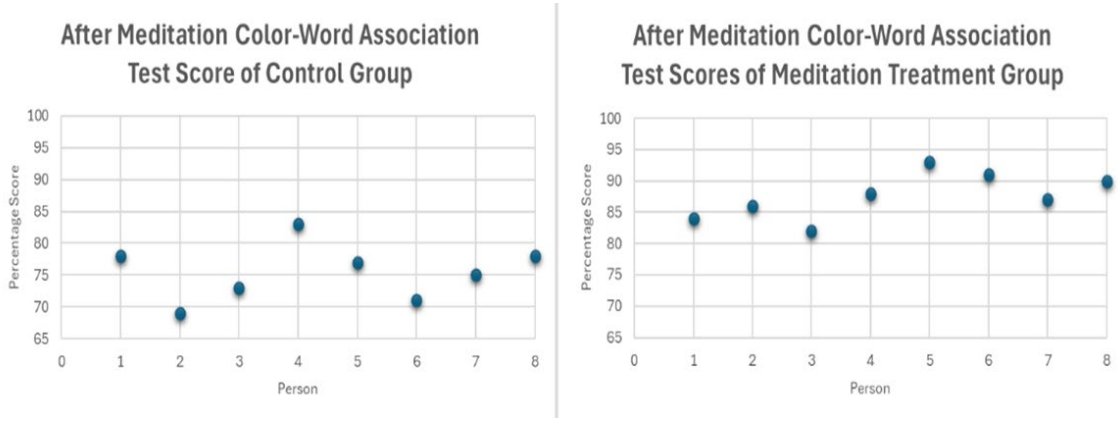

Figure 7 (left). The scores of the meditation group participants on the color-word association test before the meditation treatment.

Figure 8 (right). The scores of the meditation group participants on the color-word association test after the meditation treatment.

(Source: Mukund, 2024)

Figures 7 and 8 are scatterplots of the color-word association test scores of the no mindfulness treatment group and the color-word association test scores of the mindfulness treatment group, respectively. When looking at where the values tend in both graphs, it can be clearly seen that the values in Figure 7 tend to be lower than the values in Figure 8. This tendency was verified by a final ANOVA statistical test with an alpha level of 0.05. At this significance level, the ANOVA test outputted a p-value of $p = 0.0478$, meaning that $p < 0.05$. This result shows that there was a significant increase in the color-word association test scores between the no mindfulness meditation control group and the mindfulness meditation group after the mindfulness session was held with the mindfulness meditation group.

Conclusion and Recommendations

This research verified the experimental hypothesis that mindfulness meditation affects memory and concentration in humans which in turn can be applied to determining its effects on neurodegenerative conditions. This was done by having participants engage in a mindfulness meditation session and having the mindfulness treatment group and a control group take word memory tests and color-word association tests before and after the mindfulness session. It was shown that there was a statistically significant increase between the before and after mindfulness meditation test score results in both the word memory and color-word association tests of the mindfulness treatment group (Figures 1, 2, 3, and 4). Also, there was also a statistically significant increase between both the word memory and color-word association test scores of the no mindfulness control group and the mindfulness treatment group (Figures, 5, 6, 7, and 8). These results show that memory and concentration are significantly improved after mindfulness sessions are done as opposed to when they are not, and this result could be possibly generalized to a multitude of neurodegenerative conditions like Alzheimer's disease, Parkinson's disease, and mental health disorders like depression. Although a definitive correlation cannot be drawn from this research, with further research, the correlation can be made. To expand on the further research studies that could be done, it would be ideal if some limitations are taken into account and remedied in these studies. Some limitations of this particular study were that there were a fairly small number of research participants (n=16) in total, and there was only one trial of a mindfulness session. Another limitation was that there were only two readily available cognitive tests, which were the word memory test and the color-word association test. In order to address these limitations, future studies could entail more participants, trials of mindfulness, and cognitive tests. The research and cognitive tests in the future could not only be specific to memory and concentration, but also to many other vital functions like learning ability and coordination. One more interesting addition to this research could be that the mindfulness sessions and tests are proctored at different times of the day and in different settings and environments. All of these recommendations put together in further research would ensure comprehensive coverage of numerous functions that are lacking when neurodegenerative diseases and disorders are present, and a stronger conclusion that mindfulness meditation positively impacts the progression and treatment of neurodegenerative diseases and disorders can be established.

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