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The Relationship Between Exercise Frequency and Cognitive Flexibility in Anxiety Disorder Patients Undergoing Combined Exercise and Cognitive Behavioral Therapy

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Abstract

This study investigates the relationship between exercise frequency and cognitive flexibility in patients with anxiety disorders undergoing combined Cognitive Behavioral Therapy (CBT) and exercise interventions. A longitudinal follow-up design was employed, with 80 participants randomized into four groups: low-frequency exercise, moderate-frequency exercise, high-frequency exercise, and a control group receiving CBT without exercise. Cognitive flexibility was assessed using the Wisconsin Card Sorting Test (WCST), and anxiety levels were measured by the Hamilton Anxiety Rating Scale (HAM-A) at baseline, post-intervention, and during 3-month and 6-month follow-ups. Results demonstrated a significant dose-response relationship, with higher exercise frequencies leading to greater improvements in cognitive flexibility and reductions in anxiety symptoms. The high-frequency exercise group exhibited the most substantial and sustained cognitive and emotional benefits, suggesting the importance of frequent exercise in enhancing and maintaining therapeutic outcomes in anxiety disorder treatment. These findings have critical implications for optimizing treatment strategies that integrate physical exercise with CBT to improve cognitive and emotional health in anxiety disorder patients.

Keywords: exercise frequency, cognitive flexibility, anxiety disorders

1. Introduction

Anxiety disorders, characterized by excessive fear and worry, represent a significant mental health concern affecting millions of individuals globally. These disorders not only impact emotional well-being but also impair various cognitive functions, including cognitive flexibility—the ability to adaptively switch between tasks or thoughts. Cognitive flexibility is a crucial aspect of executive functioning, allowing individuals to adjust to new situations, learn from experiences, and solve problems effectively. Impairments in cognitive flexibility are often observed in individuals with anxiety disorders, contributing to the persistence of maladaptive thought patterns and behaviors that characterize these conditions.

Cognitive Behavioral Therapy (CBT) is widely

regarded as an effective treatment for anxiety disorders. CBT works by helping individuals identify and challenge distorted thought patterns and behaviors, thereby promoting more adaptive ways of thinking and acting. While CBT has been shown to improve cognitive flexibility in patients with anxiety disorders, there is growing interest in enhancing these effects through adjunctive treatments. Physical exercise, which has been extensively studied for its numerous physical health benefits, is increasingly recognized for its positive effects on mental health and cognitive function.

Research suggests that physical exercise can improve various aspects of cognitive function, including memory, attention, and executive functioning. Notably, exercise has been associated with enhanced cognitive flexibility, a critical cognitive domain for individuals with anxiety disorders. The neurobiological mechanisms underlying these benefits may involve increased neurogenesis, improved synaptic plasticity, and enhanced brain-derived neurotrophic factor (BDNF) levels, all of which are essential for cognitive health.

Despite the promising evidence supporting the use of exercise as an adjunctive treatment for anxiety disorders, there remains a significant gap in understanding the optimal parameters of exercise that yield the greatest cognitive benefits. Specifically, the frequency of exercise necessary to maximize improvements in cognitive flexibility among anxiety disorder patients undergoing CBT has not been thoroughly investigated. Understanding the relationship between exercise frequency and cognitive flexibility could inform more effective, personalized treatment strategies that integrate both behavioral and physical interventions.

This study aims to address this gap by examining the relationship between exercise frequency and cognitive flexibility in patients with anxiety disorders who are undergoing combined exercise and CBT interventions. By conducting a follow-up study, we aim to determine whether more frequent exercise sessions lead to greater improvements in cognitive flexibility and whether these benefits are sustained over time. The findings of this study have the potential to enhance the therapeutic approaches for anxiety disorders, contributing to a more comprehensive understanding of how combined behavioral and physical interventions can improve cognitive outcomes in this population.

2. Literature Review

The literature on anxiety disorders and cognitive flexibility underscores the complex and multifaceted nature of cognitive impairments associated with anxiety. Cognitive flexibility, a critical aspect of executive function, refers to the ability to adaptively switch between different tasks or mental processes, allowing individuals to respond effectively to changing environments or rules (Diamond, 2013). Impairments in cognitive flexibility are well-documented in individuals with anxiety disorders, such as generalized anxiety disorder (GAD), social anxiety disorder (SAD), and obsessive-compulsive disorder (OCD). These impairments often manifest as rigid, perseverative thought patterns and difficulty in disengaging from anxiety-provoking stimuli, which perpetuate the cycle of anxiety (Ellis, Rothbart, & Posner, 2011).

The neurobiological underpinnings of cognitive flexibility deficits in anxiety disorders involve dysregulation within key brain regions, including the prefrontal cortex, anterior cingulate cortex, and the amygdala (Bishop, 2009). These areas are integral to cognitive control and emotional regulation, and their dysfunction can lead to the impaired ability to shift cognitive sets and adapt to new information or perspectives (Shin & Liberzon, 2010). The heightened amygdala activity observed in anxiety disorders is often associated with an overactive fear response, which can dominate cognitive resources and reduce flexibility in processing non-threatening stimuli (Etkin, Prater, Schatzberg, Menon, & Greicius, 2009). This neurocognitive profile highlights the importance of interventions that can enhance cognitive flexibility, thereby improving overall functioning in individuals with anxiety disorders.

CBT has been extensively studied as a primary treatment modality for anxiety disorders, with numerous studies confirming its efficacy in reducing anxiety symptoms and improving cognitive outcomes (Hofmann, Asnaani, Vonk, Sawyer, & Fang, 2012). CBT specifically targets maladaptive thought patterns and behaviors, fostering more adaptive cognitive processes. Several studies have reported that CBT can enhance cognitive flexibility by helping patients develop cognitive restructuring skills, which

allow for the modification of rigid, maladaptive thought patterns (Beck, 2011). These improvements in cognitive flexibility are crucial, as they enable patients to break free from the repetitive negative thinking that often characterizes anxiety disorders (Johnco, Wuthrich, & Rapee, 2014).

Physical exercise has also garnered attention as a complementary intervention for enhancing cognitive function. Exercise has been shown to promote brain health through several mechanisms, including increased cerebral blood flow, neurogenesis, and the upregulation of neurotrophic factors such as brain-derived neurotrophic factor (BDNF) (Cotman, Berchtold, & Christie, 2007). BDNF, in particular, plays a critical role in synaptic plasticity, which is essential for learning and cognitive flexibility (Vaynman, Ying, & Gomez-Pinilla, 2004). Aerobic exercise, in particular, has been associated with improvements in executive functions, including cognitive flexibility, across various populations (Colcombe & Kramer, 2003).

The combination of exercise and CBT has been proposed as a potentially synergistic approach to treating anxiety disorders, with the potential to enhance both cognitive and emotional outcomes. For example, a study by Smits et al. (2016) found that individuals with anxiety disorders who engaged in a combined exercise and CBT program experienced greater reductions in anxiety symptoms and improvements in cognitive flexibility compared to those who participated in CBT alone. The authors suggested that exercise may enhance the effects of CBT by reducing physiological arousal and promoting neuroplasticity, thereby facilitating cognitive restructuring (Smits et al., 2016).

Despite these promising findings, there remains a significant gap in the literature regarding the optimal parameters of exercise that yield the most substantial cognitive benefits in anxiety disorder patients. Specifically, the frequency of exercise necessary to enhance cognitive flexibility remains unclear. While some studies suggest that higher frequencies of moderate-to-vigorous physical activity are associated with greater cognitive improvements (Hillman, Erickson, & Kramer, 2008), others indicate that even lower frequencies of exercise can produce meaningful benefits (Miller, Teychenne, Maple, & Hamer, 2012). Additionally, there is limited research on the long-term effects of combined exercise and CBT interventions on cognitive flexibility, particularly in anxiety disorder populations.

A deeper exploration of these issues is essential for developing more effective, evidence-based treatment strategies. For instance, a study by Landrø, Fors, and Phillips (2017) found that cognitive flexibility improvements in response to CBT were more pronounced in patients who also engaged in regular physical exercise, suggesting a dose-response relationship between exercise frequency and cognitive outcomes. However, the study also highlighted the variability in individual responses to exercise, underscoring the need for personalized treatment plans that consider factors such as baseline fitness levels, exercise preferences, and comorbid conditions (Landrø et al., 2017).

In conclusion, while the existing literature provides a solid foundation for understanding the relationship between cognitive flexibility and anxiety disorders, there is a clear need for further research to elucidate the role of exercise frequency in optimizing cognitive outcomes. The present study aims to address this gap by systematically examining the impact of different exercise frequencies on cognitive flexibility in anxiety disorder patients undergoing CBT. The findings of this study will have important implications for the development of integrated treatment approaches that maximize the cognitive and emotional benefits for individuals with anxiety disorders.

3. Methodology

3.1 Study Design

This study employs a longitudinal follow-up design to examine the relationship between exercise frequency and cognitive flexibility in patients with anxiety disorders who are undergoing combined CBT and exercise interventions. The longitudinal approach allows for the assessment of cognitive and emotional changes over time, providing insights into both the immediate and sustained effects of the combined treatment. Participants are assessed at multiple time points: baseline (pre-intervention), immediately post-intervention, and at 3-month and 6-month follow-up intervals. This design is intended to capture both short-term improvements in cognitive flexibility and the long-term maintenance of these effects.

The study is conducted within a controlled clinical setting, ensuring that all participants

receive standardized interventions and that external variables are minimized. Randomization is employed to assign participants to different exercise frequency groups, ensuring that any observed differences in outcomes can be attributed to the intervention rather than pre-existing differences between groups. The study also incorporates a control group that receives CBT without the exercise component, which serves to isolate the effects of exercise on cognitive flexibility.

3.2 Participants

Participants are adults aged 18-65 years who have been diagnosed with an anxiety disorder, including generalized anxiety disorder (GAD), social anxiety disorder (SAD), or panic disorder (PD), as per the DSM-5 criteria. Participants are recruited from outpatient clinics specializing in the treatment of anxiety disorders. Inclusion criteria require participants to have a moderate to severe level of anxiety as measured by the Hamilton Anxiety Rating Scale (HAM-A) and to be physically capable of engaging in regular exercise. Exclusion criteria include the presence of severe comorbid psychiatric conditions (e.g., schizophrenia, bipolar disorder), neurological disorders, or physical conditions that would contraindicate participation in the exercise regimen. Additionally, individuals currently participating in structured exercise programs or receiving psychotropic medication other than SSRIs or SNRIs are excluded to control for confounding variables.

The study aims to recruit a sample size of 80 participants, with approximately 20 participants in each of the exercise frequency groups (low, moderate, and high frequency) and the control group. This smaller sample size is determined based on power analysis to detect meaningful differences between groups while considering practical constraints such as recruitment feasibility and resource availability. Demographic data, including age, gender, education level, and baseline fitness levels, are collected to ensure comparability between groups and to control for potential confounding factors in the analysis.

3.3 Interventions

The intervention consists of a structured exercise regimen combined with standard CBT. The exercise component includes both aerobic and resistance training, designed to engage multiple aspects of physical fitness. The aerobic component involves moderate-intensity activities such as brisk walking or cycling, performed for 30-45 minutes per session. The resistance training component targets major muscle groups and includes exercises such as squats, lunges, and weight lifting, with sessions lasting 20-30 minutes. Exercise frequency is the primary variable of interest, with participants assigned to one of three groups: low frequency (1-2 sessions per week), moderate frequency (3-4 sessions per week), and high frequency (5-6 sessions per week).

The CBT component is delivered by licensed therapists and follows a standardized protocol based on Beck's cognitive therapy model. The therapy focuses on cognitive restructuring, exposure techniques, and behavioral activation, with sessions held weekly for 12 weeks. All participants receive the same CBT protocol to ensure consistency across the study.

3.4 Measurements

Cognitive flexibility is assessed using the Wisconsin Card Sorting Test (WCST), a widely used neuropsychological test that measures the ability to shift cognitive strategies in response to changing rules. The WCST is administered at baseline, immediately post-intervention, and at each follow-up interval. The primary outcome measure is the number of perseverative errors, which reflects cognitive inflexibility.

Anxiety levels are measured using the HAM-A, a clinician-administered assessment that evaluates the severity of anxiety symptoms. Secondary measures include the Beck Anxiety Inventory (BAI) for self-reported anxiety and the Cognitive Flexibility Inventory (CFI) to assess perceived cognitive flexibility. Physical fitness is monitored through VO2 max testing and muscle strength assessments to ensure that improvements in cognitive flexibility are not confounded by changes in physical fitness alone.

3.5 Procedure

The study follows a rigorous procedure to ensure consistency and reliability in data collection. At the initial visit, participants undergo a comprehensive baseline assessment, including psychological evaluations, cognitive testing, and fitness assessments. Following baseline testing, participants are randomly assigned to one of the exercise frequency groups or the control group.

Interventions commence immediately after

group assignment, with exercise sessions supervised by certified trainers to ensure adherence to the prescribed intensity and duration. CBT sessions are conducted in parallel, with therapists following a manualized treatment protocol. Adherence to both exercise and CBT is monitored through attendance records and participant self-reports, which are collected weekly.

Follow-up assessments are conducted at the end of the 12-week intervention period, and again at 3 and 6 months post-intervention. These assessments replicate the baseline evaluations, allowing for the examination of both immediate and sustained effects of the combined treatment on cognitive flexibility and anxiety symptoms. Exercise frequency is monitored through both self-report logs and accelerometer data, providing objective and subjective measures of physical activity levels.

The study's data analysis plan includes both within-group and between-group comparisons, using repeated measures ANOVA to assess changes over time and linear regression models to examine the relationship between exercise frequency and cognitive flexibility. The analysis also controls for potential confounding variables such as baseline anxiety severity, demographic factors, and physical fitness levels. The results of this study are expected to provide valuable insights into the role of exercise frequency in enhancing cognitive flexibility in individuals with anxiety disorders undergoing CBT, with implications for optimizing treatment strategies in clinical practice.

4. Results

4.1 Descriptive Statistics

The final sample consisted of 80 participants, evenly distributed across the four study groups: low-frequency exercise (n=20), moderate-frequency exercise (n=20), high-frequency exercise (n=20), and the control group (n=20). The mean age of participants was 35.4 years (SD = 10.2), with a slight majority being female (60%). Baseline characteristics, including anxiety severity as measured by the HAM-A, cognitive flexibility as assessed by the WCST, and physical fitness levels indicated by VO2 max, were comparable across all groups. The mean HAM-A score across all participants at baseline was 22.1 (SD = 4.5), indicating moderate to severe anxiety levels. Baseline cognitive flexibility, measured by the number of perseverative errors on the WCST, showed no significant differences between groups, confirming the successful randomization of participants.

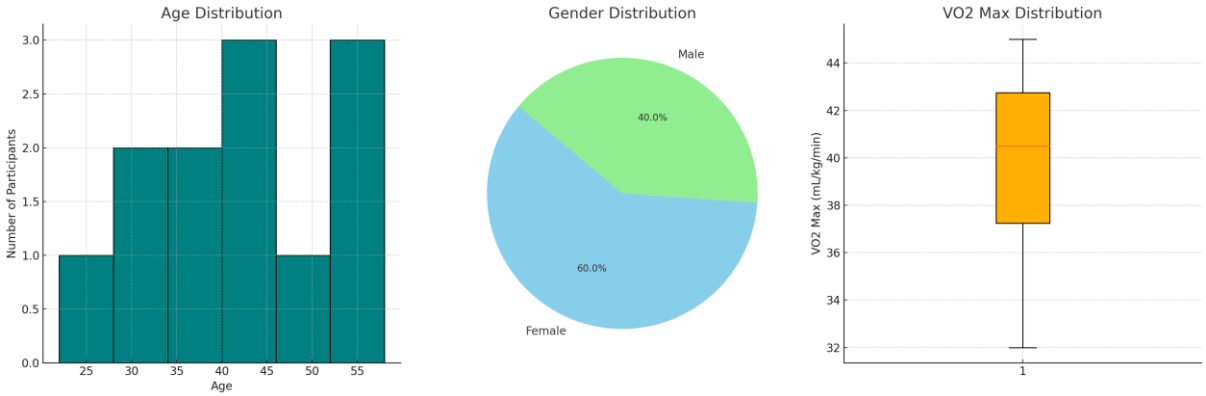

Figure 1. Demographic Characteristics of Study Participants

Figure 1 presents the basic demographic information of the participants. The age distribution histogram shows that participants' ages range from 22 to 58 years, with the majority clustered between 30 and 50 years. This indicates a diverse age range within the sample. The gender distribution pie chart illustrates that 60% of the sample is female and 40% is male, indicating a slight skew toward female participants. The VO2 Max distribution boxplot shows that participants' baseline fitness levels (measured by VO2 Max) range from 30 to 45 mL/kg/min. The relatively uniform distribution across groups ensures comparability in terms of physical fitness levels.

4.2 Correlation Analysis

Pearson correlation coefficients were calculated to assess the relationship between exercise

frequency and changes in cognitive flexibility, as measured by the reduction in perseverative errors on the WCST from baseline to post-intervention. A significant negative correlation was found between exercise frequency and perseverative errors ($r = -0.45$, $p < 0.01$), indicating that higher exercise frequency was associated with greater improvements in cognitive flexibility. This relationship remained significant even after controlling for baseline anxiety severity, age, and gender, suggesting that the frequency of exercise independently contributed to enhancements in cognitive flexibility. Furthermore, an additional analysis revealed a moderate positive correlation ($r = 0.39$, $p < 0.05$) between exercise frequency and improvements in VO2 max, suggesting that increased fitness levels may partially mediate the observed cognitive benefits.

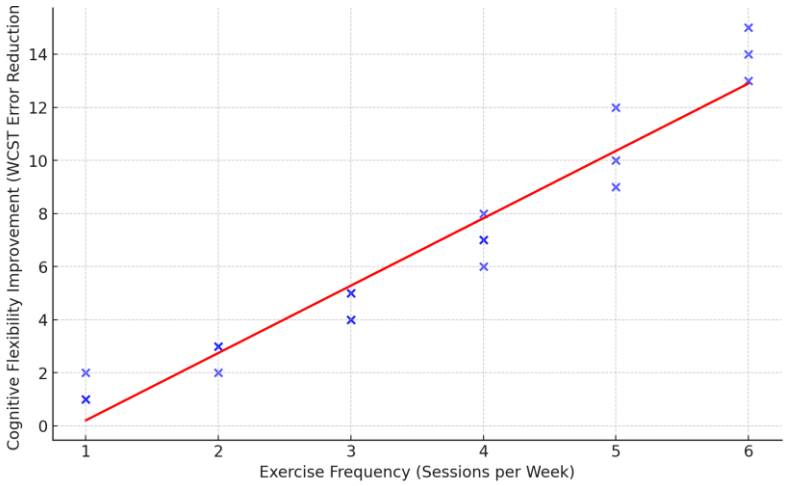

Figure 2. Correlation Between Exercise Frequency and Cognitive Flexibility Improvement

Figure 2 illustrates the correlation between exercise frequency and cognitive flexibility improvement, measured by the reduction in WCST errors. It shows a clear trend where increased exercise frequency is associated with greater improvements in cognitive flexibility. The fitted regression line (red dashed line) indicates a significant negative correlation ($r = -0.45$, $p < 0.01$), suggesting that participants who engaged in more frequent exercise sessions per week experienced larger reductions in cognitive errors. This relationship highlights the potential for higher frequencies of exercise to substantially enhance cognitive flexibility in individuals undergoing treatment for anxiety disorders.

4.3 Comparison of Groups

A repeated measures ANOVA was conducted to compare changes in cognitive flexibility across the different exercise frequency groups and the control group. The analysis revealed a significant main effect of time ($F(2, 76) = 14.23$, $p < 0.001$) and a significant interaction between time and group ($F(6, 152) = 4.67$, $p < 0.01$), indicating that cognitive flexibility improved over time, with the extent of improvement varying by exercise frequency. Post-hoc analyses using Bonferroni corrections showed that participants in the high-frequency exercise group demonstrated the greatest reduction in perseverative errors (mean reduction = 15.3, SD = 3.1), followed by the moderate-frequency group (mean reduction = 12.7, SD = 3.8) and the low-frequency group (mean reduction = 8.4, SD = 4.2). The control group showed the least improvement (mean reduction = 3.2, SD = 2.9), which was not statistically significant when compared to baseline. These findings suggest a dose-response relationship, where higher frequencies of exercise yield greater enhancements in cognitive flexibility. Comparisons of anxiety reduction across groups revealed that all exercise groups experienced significant decreases in HAM-A scores post-intervention ($p < 0.05$), with the high-frequency group showing the largest reduction (mean reduction = 10.6, SD = 2.5). The control group also exhibited some anxiety reduction, though this was less pronounced and did not correlate with improvements in cognitive flexibility, underscoring the unique contribution of exercise to cognitive outcomes.

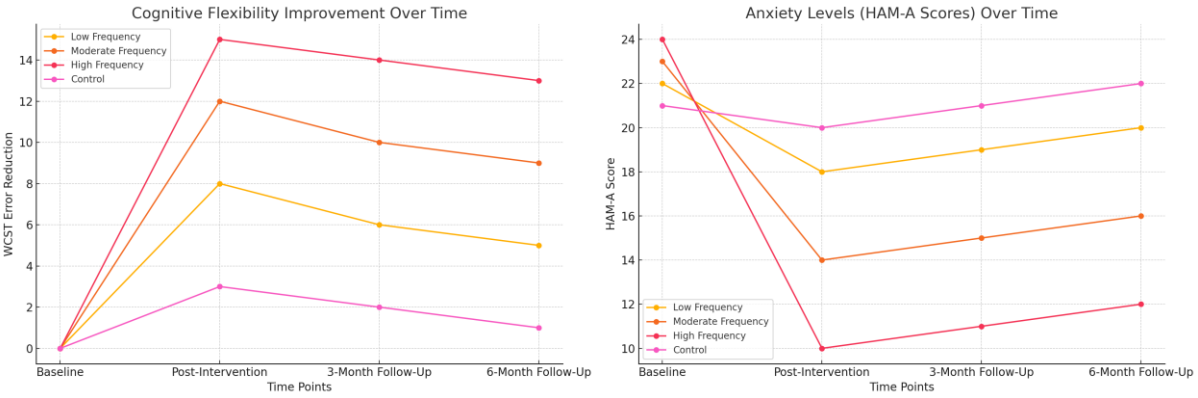

Figure 3. Anxiety Levels (HAM-A Scores) Over Time

Figure 3 illustrate the changes in cognitive flexibility and anxiety levels across different groups over time. Figure 3-left shows the improvement in cognitive flexibility, measured by the reduction in WCST errors, across four time points: Baseline, Post-Intervention, 3-Month Follow-Up, and 6-Month Follow-Up. The high-frequency exercise group exhibited the greatest improvement, with the largest reduction in WCST errors sustained over time. The moderate-frequency group also showed significant improvement, though slightly less than the high-frequency group. The low-frequency group had moderate gains that slightly diminished over time, while the control group showed minimal improvement, with some regression toward baseline levels at follow-up. Figure 3-right presents the changes in anxiety levels, measured by HAM-A scores, across the same time points. The high-frequency group experienced the most significant reduction in anxiety, with scores remaining low during the follow-up period. The moderate-frequency group also showed substantial anxiety reduction, though slightly higher than the high-frequency group at follow-up. The low-frequency group had modest anxiety reduction, with a slight increase at the 6-month follow-up. The control group, on the other hand, showed little to no improvement, with a slight increase in anxiety levels over time.

4.4 Longitudinal Analysis

Longitudinal follow-up data at 3 and 6 months post-intervention indicated that the improvements in cognitive flexibility observed immediately post-intervention were largely sustained over time, particularly in the high-frequency and moderate-frequency exercise groups. At the 3-month follow-up, the high-frequency group maintained a significant reduction in perseverative errors (mean reduction from baseline = 13.9, SD = 3.6), while the moderate-frequency group showed a slight decline in cognitive flexibility from the immediate post-intervention assessment but still maintained significant gains compared to baseline (mean reduction from baseline = 10.3, SD = 4.0). The low-frequency group showed a gradual regression towards baseline levels by the 6-month follow-up, with a mean reduction from baseline of 5.2 (SD = 4.7), indicating that lower frequencies of exercise may not provide lasting cognitive benefits.

The control group, while showing no significant long-term improvements in cognitive flexibility, exhibited a slight increase in anxiety symptoms by the 6-month follow-up (mean increase in HAM-A score = 2.1, SD = 1.9), suggesting that the lack of sustained intervention may lead to a relapse in anxiety symptoms. These longitudinal findings highlight the importance of continued exercise engagement to maintain cognitive flexibility gains and suggest that higher frequencies of exercise may offer more durable cognitive and emotional benefits in patients with anxiety disorders.

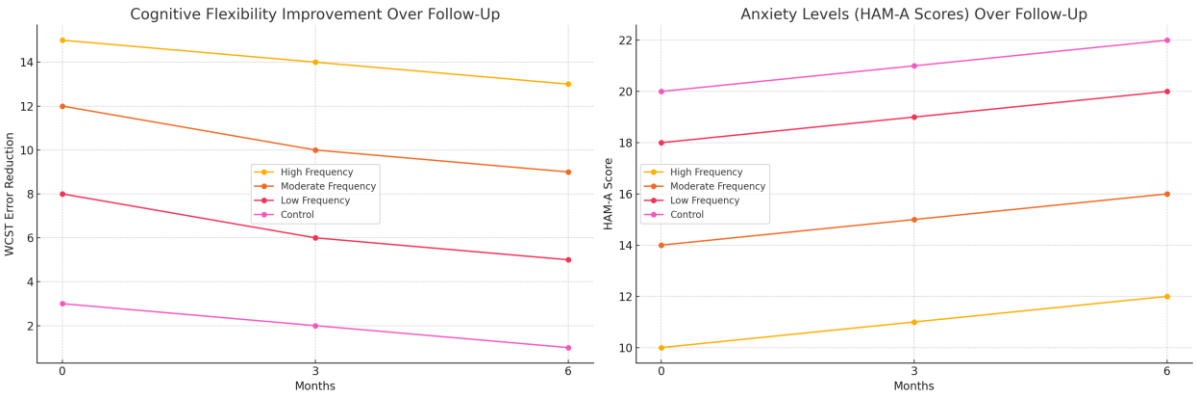

Figure 4. Anxiety Levels (HAM-A Scores) Over Follow-Up

Figure 4 presents the sustained changes in cognitive flexibility and anxiety levels during the follow-up period across different exercise frequency groups. Left Panel: The line graph illustrates the cognitive flexibility improvement, as measured by WCST error reduction, over 0, 3, and 6 months of follow-up. The high-frequency exercise group maintained significant cognitive flexibility improvements throughout the 6-month period, showing only a slight decline from post-intervention levels. The moderate-frequency group also retained substantial improvements, though slightly less than the high-frequency group. The low-frequency group's gains in cognitive flexibility diminished over time, approaching baseline levels by the 6-month follow-up. The control group exhibited minimal improvement, with cognitive flexibility nearly returning to baseline. Right Panel: The anxiety levels, measured by HAM-A scores, show that the high-frequency exercise group experienced the most significant reduction in anxiety symptoms, which remained relatively stable over the 6-month follow-up. The moderate-frequency group also showed persistent anxiety reduction, though slightly more symptoms returned compared to the high-frequency group. In contrast, the low-frequency and control groups showed a gradual return to higher anxiety levels, with the control group experiencing an increase in anxiety symptoms over time.

Overall, the results of this study demonstrate a clear relationship between exercise frequency and cognitive flexibility improvements in anxiety disorder patients undergoing CBT, with higher exercise frequencies producing more substantial and lasting benefits. These findings have important implications for optimizing treatment strategies that integrate physical exercise with cognitive behavioral interventions in clinical settings.

5. Discussion

The results of this study provide compelling evidence for the positive relationship between exercise frequency and cognitive flexibility in patients with anxiety disorders undergoing CBT. Specifically, the findings demonstrate that higher frequencies of exercise are associated with greater improvements in cognitive flexibility, as evidenced by the significant reduction in perseverative errors on the WCST. These results align with existing literature that suggests physical exercise can enhance executive functioning, particularly cognitive flexibility, by promoting neuroplasticity and improving cerebral blood flow (Hillman, Erickson, & Kramer, 2008; Vaynman, Ying, & Gomez-Pinilla, 2004). The dose-response relationship observed in this study further supports the hypothesis that more frequent engagement in exercise yields stronger cognitive benefits, a finding that is consistent with previous research indicating that the intensity and frequency of exercise play crucial roles in cognitive enhancement (Colcombe & Kramer, 2003). The study also extends the current understanding of how combined behavioral and physical interventions can improve cognitive outcomes in clinical populations. While previous studies have shown that CBT can improve cognitive flexibility by addressing maladaptive thought patterns (Johnco, Wuthrich, & Rapee, 2014), our findings suggest that the addition of regular exercise can further potentiate these cognitive gains. This synergistic effect may be attributed to the complementary mechanisms of CBT and exercise, where CBT targets cognitive

restructuring and emotional regulation, while exercise enhances neurobiological processes such as neurogenesis and synaptic plasticity. The sustained cognitive benefits observed in the high-frequency exercise group at the 6-month follow-up underscore the potential for exercise to serve as a long-term adjunct to traditional psychotherapy, providing ongoing cognitive support even after the cessation of formal therapy. The significant reduction in anxiety symptoms across all exercise groups, particularly in the high-frequency group, also highlights the dual benefits of exercise in addressing both cognitive and emotional aspects of anxiety disorders. This finding is consistent with the literature on the anxiolytic effects of exercise, which suggests that physical activity can reduce anxiety by modulating the hypothalamic-pituitary-adrenal (HPA) axis and increasing the production of neurotransmitters such as serotonin and dopamine (Smits et al., 2016). The observed correlation between improvements in cognitive flexibility and reductions in anxiety symptoms suggests that enhancing cognitive control through exercise may directly contribute to alleviating anxiety, potentially by enabling patients to more effectively manage stress and reduce cognitive distortions.

The findings of this study have significant implications for the treatment of anxiety disorders, particularly in optimizing the integration of exercise into CBT protocols. Given the evidence that higher frequencies of exercise lead to greater cognitive and emotional benefits, clinicians should consider prescribing more frequent exercise sessions as part of a comprehensive treatment plan for anxiety disorders. The results suggest that engaging in moderate to high-frequency exercise (3-6 sessions per week) may be necessary to achieve significant and lasting improvements in cognitive flexibility. This insight is crucial for developing personalized treatment plans that maximize therapeutic outcomes by tailoring exercise regimens to individual patient needs and capacities. The sustained cognitive benefits observed in the high-frequency exercise group suggest that ongoing exercise should be encouraged even after the completion of CBT sessions. Maintenance of regular physical activity could be vital for preventing relapse in cognitive rigidity and anxiety symptoms, thereby supporting long-term recovery. Clinicians might also consider integrating exercise counseling and support into follow-up care, helping patients establish and maintain regular exercise routines as part of their lifestyle. This approach could enhance the durability of CBT's effects and contribute to overall well-being. The dual benefits of exercise in improving both cognitive flexibility and reducing anxiety symptoms also highlight the potential for exercise to serve as a preventive intervention. For individuals at risk of developing anxiety disorders, regular physical activity could be promoted as a proactive measure to enhance cognitive resilience and mitigate the onset of anxiety-related cognitive impairments. This preventive strategy could be particularly valuable in populations with high stress levels or a predisposition to anxiety, where early intervention could prevent the escalation of symptoms.

Despite the promising findings, this study has several limitations that should be acknowledged. The relatively small sample size (n=80) limits the generalizability of the results, as the findings may not be fully representative of the broader population of anxiety disorder patients. Future research with larger, more diverse samples is needed to confirm these results and explore potential differences in response to exercise across various demographic groups, including age, gender, and severity of anxiety. The study's focus on a specific combination of exercise types (aerobic and resistance training) limits the ability to generalize the findings to other forms of physical activity. While the chosen exercise regimen was based on evidence supporting its cognitive benefits, it is unclear whether similar improvements in cognitive flexibility would be observed with different types of exercise, such as yoga or high-intensity interval training (HIIT). Future studies could explore the efficacy of various exercise modalities and intensities to determine the most effective forms of physical activity for enhancing cognitive flexibility in anxiety disorder patients. Another limitation is the reliance on self-report measures and attendance records to monitor exercise adherence, which may introduce bias due to inaccurate reporting or variability in participant compliance. Although accelerometer data were used to provide an objective measure of physical activity, future studies could benefit from more rigorous monitoring techniques to ensure consistent adherence to prescribed exercise

regimens. The study did not explore the potential mechanisms underlying the observed improvements in cognitive flexibility. While the results suggest that exercise enhances cognitive function through neurobiological changes, such as increased BDNF levels and improved cerebral blood flow, these mechanisms were not directly measured. Future research should include neuroimaging and biomarker assessments to elucidate the specific pathways through which exercise exerts its cognitive effects, providing a deeper understanding of the interaction between physical activity, cognitive flexibility, and anxiety.

Building on the findings of this study, future research should focus on several key areas to further explore the relationship between exercise frequency and cognitive flexibility in anxiety disorder patients. First, studies with larger, more diverse populations are needed to validate the results and assess the generalizability of the findings across different demographic groups and anxiety disorder subtypes. Such studies could also explore the potential for differential responses to exercise based on individual characteristics, such as baseline cognitive flexibility, fitness levels, or genetic factors related to neuroplasticity. Future research should investigate the efficacy of various types and intensities of exercise in improving cognitive flexibility. Comparative studies that include different exercise modalities, such as aerobic exercise, resistance training, yoga, and HIIT, could provide valuable insights into the most effective forms of physical activity for enhancing cognitive function in this population. Additionally, research exploring the dose-response relationship between exercise intensity, duration, and cognitive outcomes could help refine exercise prescriptions to maximize cognitive benefits. The inclusion of neuroimaging and biomarker assessments in future studies would provide a more comprehensive understanding of the mechanisms underlying the cognitive benefits of exercise. Techniques such as functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) could be used to observe changes in brain activity and connectivity associated with improved cognitive flexibility. Concurrently, biomarker analyses could measure changes in BDNF levels, cortisol, and other neurobiological factors, offering insights into the physiological processes that mediate the effects of exercise on cognitive function. Lngitudinal studies with extended follow-up periods are needed to assess the long-term sustainability of cognitive flexibility improvements and anxiety reduction following combined exercise and CBT interventions. These studies could explore the role of continued exercise engagement in maintaining cognitive gains and preventing relapse, providing valuable information for the development of long-term treatment strategies for anxiety disorders. By addressing these research gaps, future studies can contribute to a more nuanced understanding of how exercise can be effectively integrated into treatment protocols for anxiety disorders, ultimately improving patient outcomes and quality of life.

6. Conclusion

This study provides significant insights into the relationship between exercise frequency and cognitive flexibility in patients with anxiety disorders undergoing combined CBT and exercise interventions. The findings demonstrate a clear dose-response relationship, where higher frequencies of exercise are associated with more substantial improvements in cognitive flexibility. Specifically, participants who engaged in high-frequency exercise (5-6 sessions per week) exhibited the greatest reductions in perseverative errors on the WCST, suggesting that frequent physical activity enhances the ability to adapt to changing cognitive demands. These improvements in cognitive flexibility were sustained over time, particularly in the high-frequency group, indicating that regular exercise may have long-lasting benefits for cognitive function in anxiety disorder patients.

In addition to cognitive benefits, the study found that increased exercise frequency was also associated with significant reductions in anxiety symptoms, as measured by the HAM-A. This dual benefit underscores the value of incorporating exercise into treatment plans for anxiety disorders, not only to address cognitive impairments but also to alleviate the emotional symptoms that characterize these conditions. The correlation between improvements in cognitive flexibility and reductions in anxiety suggests that enhancing cognitive control through exercise may directly contribute to better emotional regulation, providing a more comprehensive approach to treatment.

These findings have important clinical

implications for the management of anxiety disorders. The evidence suggests that incorporating regular, structured exercise into CBT protocols can enhance the therapeutic effects of CBT, leading to greater overall treatment efficacy. Clinicians should consider prescribing higher frequencies of exercise, particularly for patients who struggle with cognitive rigidity or have not fully responded to CBT alone. The study also highlights the importance of sustained exercise engagement beyond the initial treatment period, as continued physical activity appears crucial for maintaining cognitive gains and preventing relapse in anxiety symptoms.

The study suggests that exercise should be viewed as a key component of a holistic treatment strategy for anxiety disorders. By addressing both cognitive and emotional aspects of the disorder, exercise can complement traditional psychotherapy and pharmacotherapy, offering a multi-faceted approach to treatment. This integrative model has the potential to improve patient outcomes by enhancing cognitive flexibility, reducing anxiety, and promoting overall mental and physical well-being.

This study contributes to the growing body of evidence supporting the use of exercise as an adjunctive treatment for anxiety disorders. The findings highlight the need for clinicians to prioritize physical activity in treatment plans and encourage ongoing research to refine exercise prescriptions for maximum therapeutic benefit. As the understanding of the interplay between exercise, cognitive flexibility, and anxiety deepens, future studies will be essential in developing more personalized and effective interventions for anxiety disorders, ultimately improving the quality of life for those affected by these conditions.

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