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Integrating Physical Activity and Gut Microbiota Research in Schizophrenia: A Holistic Health Perspective

Izabela Zajkowska[1] [IZ], ORCID https://orcid.org/0009-0002-8526-7339
E-mail: zajkowska.izabela@wp.pl

Patrycja Zabrocka[2] [PN], ORCID https://orcid.org/0009-0001-5834-5277
E-mail: 39916@student.umb.edu.pl

Julia Martowska[1] [JM], ORCID https://orcid.org/0009-0006-2804-5368

E-mail: julia.wiaterek@gmail.com

Karolina Wojciechowska[1] [KW], ORCID https://orcid.org/0009-0001-7048-1335

E-mail: karolina8wojciechowska@gmail.com

Julia Baran[2] [JB], ORICID https://orcid.org/0009-0005-9569-3149

barjul99@gmail.com

Wiktor Warych[1] [WW], ORCID https://orcid.org/0009-0003-2569-6833

w.warych26@gmail.com

[1] Śniadeckiego Voivodeship Hospital in Bialystok, ul. M. C. Skłodowskiej 26, 15-278 Białystok, Poland

[2] University Clinical Hospital in Białystok, ul. M. C. Skłodowskiej 24a, 15-276 Białystok, Poland

Corresponding Author: Izabela Zajkowska, zajkowska.izabela@wp.pl

Abstract

Background: Emerging evidence underscores the critical role of the gut–brain axis in schizophrenia, linking microbial dysbiosis not only to neurotransmitter imbalances and neuroinflammation but also to physical performance and overall health status. Given the well-documented benefits of physical activity on brain plasticity and systemic inflammation, investigating its interaction with gut microbiota in schizophrenia patients represents a novel and promising frontier.

Aim: This review aims to explore how gut microbiota influence neurotransmitter synthesis and cognitive function in schizophrenia, while highlighting the potential of tailored exercise programs to modulate microbial composition, enhance neuroplasticity, and improve both psychiatric symptoms and physical fitness.

Material and Methods: On July 18, 2025, we performed a systematic literature search using a Python-based PubMed scraping tool to gather studies examining the complex relationships among schizophrenia, gut microbiota, neurotransmission, and exercise interventions.

Results: Synthesizing findings from clinical and preclinical research, we report that gut microbiota alterations affect key neurochemicals such as serotonin, GABA, and dopamine, while exercise consistently enhances hippocampal volume, cognitive performance, and microbial diversity. These synergistic effects suggest that physical activity may act as a natural modulator of the gut–brain axis in schizophrenia.

Conclusions: Integrating exercise therapy with microbiota-targeted interventions offers a promising strategy for improving neurocognitive and physical outcomes in schizophrenia patients. Such multidisciplinary approaches could redefine treatment paradigms by promoting both mental health and physical quality of life.

Key words: activity and health; activity, schizophrenia, aerobic exercise, meditation, yoga.

1. Introduction

Schizophrenia is a serious and chronic mental disorder that affects approximately 1% of the population in the United States. Though the causes of schizophrenia remain partially understood, the disorder's progression is predictable, often manifesting as positive symptoms such as hallucinations, delusions, and paranoia. While antipsychotic medications can alleviate these positive symptoms, improvements in overall patient functioning can be inconsistent.

Patients with schizophrenia often face challenges with memory, executive functions, concentration, and attention, creating significant hurdles in treatment. Additionally, negative symptoms—such as social withdrawal and reduced communication—severely impact patients' lives and their ability to reintegrate into society, contributing to the substantial social and economic costs associated with the illness. Although physical activity has been explored for treating other neuropsychiatric disorders, its effects on the neurocognitive symptoms of chronic schizophrenia are still under investigation (Tarpada and Morris 2017).

Physical activity plays a crucial role in improving the health of individuals with schizophrenia, impacting both neurobiological processes and the gut–brain axis balance. Regular exercise promotes neurogenesis and synaptic plasticity by increasing levels of brain-derived neurotrophic factor (BDNF), thereby enhancing cognitive functions such as memory and attention. It also exerts anti-inflammatory effects, reducing chronic inflammation—commonly found in schizophrenia patients—by lowering levels of pro-inflammatory cytokines like TNF-α and IL-6. Furthermore, physical activity benefits the gut microbiota, restoring homeostasis, reducing dysbiosis, and activating the vagus nerve, which supports communication between the gut and brain (Khandaker et al. 2015).

Studies suggest that aerobic exercise not only mitigates positive and negative symptoms of schizophrenia but also improves patients' motivation, quality of life, and overall functioning. These mechanisms highlight the therapeutic potential of physical activity as a complementary treatment alongside pharmacotherapy, particularly in addressing the neurobiological and immunological dysfunctions associated with schizophrenia (Rodriguez-Ayllon et al. 2023).

Low levels of physical activity can lead to the accumulation of visceral fat, which activates inflammatory pathways and promotes insulin resistance and atherosclerosis, as observed by Gleeson et al. 2011. Regular exercise has anti-inflammatory effects, such as the release of interleukin-6 (IL-6) from working muscles, increasing levels of interleukin-10 (IL-10) and the

IL-1 receptor antagonist (Kasapis and Thompson 2005). Moreover, exercise boosts the number of IL-10–secreting regulatory T cells and inhibits the expression of Toll-like receptors on monocytes, thereby reducing the inflammatory response (Flynn and McFarlin 2006). This implies that regular exercise may be crucial for improving health, including cognitive function, in people with psychiatric disorders like schizophrenia (Gleeson et al. 2011).

MRI results indicate a strong correlation between Body Mass Index (BMI) values and brain structure in patients with schizophrenia, suggesting that obesity combined with schizophrenia leads to more pronounced changes in neurostructure than those seen in individuals with only one of these conditions (McWhinney et al. 2022).

Research Objective. The aim of this publication is to analyze the available research on the impact of physical activity, yoga, and meditation on the mental health of individuals with schizophrenia, with particular focus on biological mechanisms such as the reduction of chronic inflammation, improvement of neurotransmitter balance, and gut microbiota. In light of the growing body of evidence regarding the benefits of physical exercise, it is worth examining how it can complement traditional methods of schizophrenia treatment, influencing the quality of life of patients.

Research Problems. How do physical activity, yoga, and meditation affect the mental health of individuals with schizophrenia through biological mechanisms, and to what extent can they complement traditional treatments?

Research Hypotheses. Regular physical activity, including aerobic exercise, yoga, and meditation, can complement traditional treatments for schizophrenia by reducing symptoms—especially negative and depressive ones—enhancing cognitive and emotional functioning, and promoting neurobiological benefits, though caution is needed due to potential risks in some patients.

2.Research materials and methods

To optimize our review, on 27.02.2025 we used PubMed scraping script run in Python environment to create a database of all publications including keywords: “schizophrenia”, ”physical activity”, “aerobic exercise”, “yoga”, “meditation”, “gut-brain axis”. We excluded publications in languages other than English, we have not included year

3. Research results

3.1. Physical activity

Pajonk and colleagues conducted a study in which patients participated in a moderate-intensity cycling program. The results showed a 12% increase in hippocampal volume, associated with improved cognitive function, particularly short-term memory. Additionally, there was an increase in brain-derived neurotrophic factor (BDNF) levels, which promote synaptic plasticity and neurogenesis. Participants also exhibited reduced negative symptoms such as apathy and anhedonia (Pajonk et al. 2010).

Curcic et al. investigated the effects of an exercise program on aerobic capacity and symptoms of schizophrenia in 80 hospitalized patients. They found significant improvements in aerobic capacity (VO_2 max) and reductions in psychopathological symptoms, as measured by the PANSS scale, in the exercise group after 12 weeks. Participants in the exercise group showed reductions in both positive and negative symptoms of schizophrenia (Curcic et al. 2017).

In a similar study, Shimada et al. examined the effects of individual and group aerobic exercise (AE) on cognitive function in patients with schizophrenia. Sixteen patients received standard care (TAU) along with AE, while 15 received TAU alone. Over 12 weeks, patients participated in two exercise sessions per week, including one individual and one group session. The results indicated significant improvements in cognitive function, intrinsic motivation, and psychiatric symptoms in the TAU + AE group (Shimada et al. 2019).

Additionally, Wang et al. conducted a randomized controlled trial investigating the effects of aerobic exercise on schizophrenia symptoms in patients treated with antipsychotic drugs. Significant reductions in positive symptoms and overall psychopathology were observed in the exercise group after 12 weeks. The reduction in negative symptoms was also notable and sustained for three months post-intervention (Wang et al. 2018).

Nuechterlein et al. assessed the effects of cognitive training and aerobic exercise on cognitive and daily functioning in individuals with first-episode schizophrenia. The combination of cognitive training and aerobic exercise led to significant improvements in cognitive test performance and functioning at work and school, compared to cognitive training alone. Increased BDNF levels were associated with improved cognitive performance, and the amount of exercise performed was strongly linked to functional improvement (Nuechterlein et al. 2022).

Kimhy et al. found that lower aerobic capacity was associated with poorer cognitive performance, including working memory, executive function, and speed of information

processing, as well as lower levels of daily functioning in patients with schizophrenia (Kimhy et al. 2014).

According to a study by Vancampfort et al., regular exercise in individuals with schizophrenia is associated with significant benefits, including weight loss and improved physical activity. The study noted that individual therapy yielded better results for weight loss than group therapy, although the evidence for improved physical functioning was somewhat incomplete (Vancampfort et al. 2019).

Soundy et al. explored the physical activity experiences of people with schizophrenia and the professionals working with them. They found that both patients and professionals identified positive aspects of physical activity, such as increased self-confidence and autonomy in decision-making (Soundy et al. 2014).

Scheewe et al. discovered that patients with schizophrenia who underwent exercise therapy had smaller grey matter volumes, larger third ventricle volumes, and thinner cerebral cortexes than a healthy control group. Improvements in cardiorespiratory fitness were associated with increases in grey matter volume and cortical thickness in the left hemisphere, although exercise alone did not directly alter brain structure (Scheewe et al. 2013).

A meta-analysis by Firth et al. found that physical activity interventions did not significantly affect body mass index, but there were improvements in patients' fitness and other cardiometabolic risk factors. They reported significant reductions in psychiatric symptoms and improvements in functioning, comorbidities, and neurocognition with approximately 90 minutes of moderate-to-vigorous physical activity per week (Firth et al. 2015).

Another meta-analysis by Dauwan et al. highlighted that physical activity reduced clinical symptoms, improved quality of life, and overall functioning. They noted reductions in the intensity of positive, negative, and depressive symptoms in patients with schizophrenia and emphasized the benefits of yoga on improving long-term memory (Dauwan et al. 2015).

3.2. Yoga

Combining physical exercise, breathing, and meditation techniques, yoga offers a holistic approach to health that can support both body and mind. Regular yoga practice helps reduce tension, improve emotional balance, and enhance focus, which is crucial for treating individuals with schizophrenia who often struggle with attention and stress management. Meditation, particularly mindfulness techniques, provides tools for managing negative thoughts, fears, and emotions, fostering self-awareness and aiding in symptom management.

Rao et al. conducted a randomized controlled trial with 89 patients to evaluate the efficacy of yoga as an adjunct to standard treatment for negative symptoms of schizophrenia. Participants attended 12 yoga sessions over two weeks and continued practice at home for another 10 weeks. Results indicated the yoga group had better improvements in negative symptoms than the control group (Rao et al. 2021).

Bhatia et al. found that yoga was well accepted, particularly by younger participants, with longer practice correlating with better visual memory scores (Bhatia et al. 2020). Govindaraj et al. studied yoga's impact on social-cognitive functioning in schizophrenics, involving 51 patients in 20 yoga sessions over six weeks. Results showed improvements in emotion recognition, social perception, and reductions in negative symptoms such as apathy and social withdrawal (Govindaraj et al. 2021).

A study by Mullapudi et al. investigated the effects of long-term yoga therapy on inflammatory pathways in schizophrenia patients. After six months, the yoga group showed significant reductions in cytokine levels (TNF-α and IL-5) and improvements in negative symptoms and functioning. TNF-α levels correlated positively with negative symptoms and socio-occupational functioning, highlighting inflammation pathways as potential biomarkers in schizophrenia (Mullapudi et al. 2023).

Ikai et al. explored the effects of Hatha yoga therapy on immunity, BDNF levels, and salivary alpha-amylase (SAA) activity in psychotic disorder patients. Participants attended weekly yoga sessions for eight weeks. Results showed no significant differences between yoga and control groups in resilience, severity of psychotic symptoms, BDNF levels, or SAA activity, indicating no confirmed beneficial effect of yoga on immune levels or stress markers (Ikai et al. 2014).

Visceglia and Lewis studied yoga therapy's impact on schizophrenia patients through specific postures, breathing exercises, and relaxation techniques. After eight weeks, significant improvements in positive and negative symptoms, as well as physical and psychological quality of life, were observed in the yoga therapy group compared to the control group (Visceglia and Lewis 2011).

Varambally et al. evaluated yoga therapy as an adjunct to schizophrenia treatment, showing significant reductions in negative symptoms and improvements in quality of life after six months (Varambally et al. 2024). Ikai et al. examined yoga's effects on postural stability in psychotic disorder patients, finding significant improvements in trunk movement, balance control, and body stability during the study's final week. However, benefits were not sustained eight weeks post-intervention (Ikai et al. 2013).

Bhatia et al. conducted a randomized controlled trial with schizophrenia patients divided into yoga, exercise, and control groups. Both active groups showed significant improvements in cognitive functions such as attention, with no significant difference between yoga and aerobic exercise effectiveness (Bhatia et al. 2014).

Behere et al. studied 66 schizophrenia patients stabilized with medication, divided into yoga, exercise, and wait-list groups. After two months, the yoga group showed significant improvements in symptoms, social functioning, and emotion recognition (Behere et al. 2010).

Duraiswamy et al. found that yoga therapy, as an adjunct to standard drug treatment, decreased psychopathological symptoms and improved social functioning and quality of life in schizophrenia patients (Duraiswamy et al. 2007).

Lin et al. used functional MRI to analyze yoga and aerobic exercise effects on neurocognition in women with early psychosis. One hundred twenty-four female patients were randomly assigned to yoga, aerobic exercise, and wait-list groups. After 12 weeks, the yoga group showed reduced amplitude of low-frequency neural fluctuations (ALFF) in the precuneus, correlating positively with reduced negative symptoms on the PANSS scale (Lin et al. 2017).

Ikai et al. conducted a 12-week study with 56 patients randomized to chair yoga or standard care. The yoga group showed significant improvements in flexibility, muscle strength, and overall sense of safety, potentially reducing fall risk (Ikai et al. 2017).

Dauwan et al.'s meta-analysis demonstrated yoga's significant effect on improving long-term memory in schizophrenia patients, suggesting it as an effective adjunct to therapy (Dauwan et al. 2015). Varambally et al. investigated yoga's efficacy in psychosis patients, finding significant reductions in clinical symptoms, including depression severity, after six weeks. Results suggest yoga may benefit acute psychosis stages when added to standard medication (Varambally et al. 2013).

Stubbs et al. emphasized the importance of yoga practice duration, finding significant reductions in psychotic symptoms and improved overall well-being with regular sessions of at least 60 minutes, 2–3 times a week. Participants reported better quality of life, social functioning, and reduced anxiety (Stubbs et al. 2018).

3.3. Meditation

Meditation is a mental exercise that can positively impact both mental and physical health. It, along with yoga, affects the gut–brain axis by reducing stress, thereby promoting a healthy gut microbiota (Ningthoujam et al. 2021). This process lowers cortisol levels and decreases the risk of inflammation, fostering a balance between pro-inflammatory and anti-inflammatory bacteria.

In the context of schizophrenia, this can alleviate symptoms by reducing inflammatory processes and improving neurochemical balance (Jamil et al. 2023).

Bhatia et al. conducted a study demonstrating that meditation combined with yoga enhances cognitive functions, such as attention and memory, in schizophrenia patients. Their findings suggest that meditation practices can improve sensory integration and emotion regulation. After three months of yoga and meditation training, the study noted moderate improvements in quality of life and in both positive and negative symptoms (Bhatia et al. 2020).

A review by Sharma et al. focused on meditation's effects on psychotic disorders, including schizophrenia. Their research highlighted that in individuals with a history of mental health issues, meditation could sometimes exacerbate psychotic symptoms. Factors like stress, insomnia, and previous psychiatric disorders can increase the risk of psychotic episodes. Therefore, it is crucial to supervise meditation practices to harness their therapeutic potential while minimizing risks (Sharma et al. 2019).

Johnson et al. investigated the impact of loving-kindness meditation (LKM) on individuals with schizophrenia spectrum disorders who exhibited significant negative symptoms. Their study involving 18 participants found that LKM effectively reduced negative symptoms, especially anhedonia, and enhanced positive emotions and psychological recovery. Participants reported a notable improvement in the experience of positive emotions (Johnson et al. 2011).

Xue et al. examined the effects of an eight-month intensive meditation-based intervention (IMI) on persistent hallucinations and delusions in men with treatment-resistant schizophrenia. The study revealed that IMI significantly reduced symptoms as measured by the PANSS scale and improved quality of life and mindfulness skills (Xue et al. 2024).

4. Discussion

A study on 56 Tibetan monks and local residents compared to a control group showed the effect of long-term meditation on the gut microbiome. Several species, including Prevotella and Bacteroides, Megamonas, and Faecalibacterium, were more abundant in the meditation group, indicating significant differences between the groups (Daley et al. 1987). Additionally, similar findings were noted in a parallel study comparing the depressive disorder group, where Prevotella species were significantly more common in the control group (Daley et al. 1987). These differences suggest that meditation might shape the microbiome, potentially affecting mental health. Bacteria such as Faecalibacterium and Megamonas possess anti-inflammatory properties, supporting immune balance. Reduced gut microbiota diversity in mental disorders

like depression can lead to inflammation linked to symptoms such as depression and anxiety. By altering the microbiota composition, meditation may enhance mental and physical health through its microbiome effects (Daley et al. 1987).

Mooventhan Aruchunan and colleagues explored yoga's impact on gut microbiota improvement in rheumatoid arthritis (RA) patients, an inflammatory disease similar to depression. Though the role of inflammation in schizophrenia is speculative, it might involve gut dysbiosis and the gut–brain axis. In RA patients, Prevotellacopri, causing Th17 cell–dependent arthritis, dominated the microbiota based on stool sample analysis. The study suggests yoga may have immunomodulatory effects on the hypothalamic–pituitary–adrenal axis, reducing inflammation. It decreases IL-6, TNF-α, IL-1a, IL-17A, C-reactive protein (CRP), and cortisol levels while increasing BDNF levels. Increased tension in the vagus nerve, notable in yoga practitioners, helps reduce TNF-α and other inflammatory cytokine production. The hypothesis is that yoga practice contributes to optimal phrenic nerve toning, promoting gut homeostasis and converting dysbiosis to symbiosis through the microbiota–gut–brain axis (Aruchunan and Nivethitha 2023).

5. Conclusions

Regular physical activity, including aerobic exercise and mind–body practices such as yoga and meditation, appears to play a significant role in improving both cognitive function and psychiatric symptoms in individuals with schizophrenia. Exercise interventions have been associated with increased hippocampal volume and elevated brain-derived neurotrophic factor (BDNF) levels, which support neuroplasticity and neurogenesis. These benefits are especially relevant for alleviating negative symptoms like apathy and diminished motivation, contributing to enhanced daily functioning and quality of life. Complementary approaches such as yoga and meditation may further aid in emotional regulation, sensory integration, and social functioning, while fostering positive emotional experiences. However, caution is warranted, as some patients—particularly those with a history of psychiatric instability—might experience exacerbation of psychotic symptoms with certain mind–body interventions. Overall, incorporating physical activity and holistic practices alongside conventional treatment offers a promising multidimensional strategy for managing schizophrenia, targeting both mental health and physical well-being.

Disclosure

Author's contribution

Conceptualization: [IZ], [PN]

Methodology: [JM], [KW], [WW]

Check: [PN], [JB], [KW]

Investigation: [JB], [IZ], [WW]
Data curation: [JM], [IZ], [PN], [JB]
Writing – rough preparation: [IZ], [KW], [JM]
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Visualization: [JB], [KW], [IZ]
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The authors declare no conflict of interest.
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