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The Influence of Physical Activity on Inflammatory Markers, Intestinal Microbiota Composition and Disease Activity in Inflammatory Bowel Disease

Authors:

Paulina Jakubczyk [1] , Piotr Widera [2], Justyna Helis [2], Maciej Michalik [2], Aleksandra Buczek [2], Hubert Bigajski [2], Aleksandra Banaś [2], Olga Bilczewska [2], Wiktoria Janik [2], Marta Handschuh [2]

Affiliations

[1] University Hospital of Karol Marcinkowski in Zielona Góra

[2] Faculty of Medical Sciences in Katowice, Medical University of Silesia

Abstract

Aim of the Study

This review investigates the relationship between physical activity and inflammatory bowel disease (IBD), focusing on inflammatory markers, gut microbiota composition, and disease

activity. The objective is to examine how exercise intensities influence inflammation, microbial diversity, and patient outcomes for IBD management.

Materials and Methods

A literature review synthesized peer-reviewed studies from 2010-2024 using PubMed, Scopus, and Embase databases, examining physical activity effects on inflammatory markers, gut microbiota, and clinical outcomes in IBD patients. Inclusion criteria emphasized human studies, excluding research unrelated to IBD or focused on animal models.

State of Knowledge

Moderate-intensity aerobic and resistance exercises reduce systemic inflammatory markers, (CRP and cytokines) and enhance gut microbiota diversity, increasing anti-inflammatory species. Low-to-moderate intensity activities improve quality of life in IBD patients. Exercise supports intestinal barrier integrity through mucin production and fatty acid synthesis. High-intensity exercise can worsen inflammation, necessitating tailored protocols.

Conclusions

Physical activity is a promising adjunctive therapy in IBD management. Moderate-intensity programs effectively maintain remission and enhance outcomes. Future research should focus on longitudinal studies, advanced omics technologies, and combined approaches with dietary and pharmacological therapies.

Keywords: “inflammatory bowel disease,” “Crohn’s disease,” “ulcerative colitis,” “physical activity.”

1. Aim of the Study

Inflammatory Bowel Disease (IBD), encompassing Crohn's Disease and Ulcerative Colitis, exhibits a complex and bidirectional relationship with physical activity that warrants comprehensive investigation. Contemporary research indicates that while IBD-related symptoms can significantly impair patients' exercise capacity and sports participation, there is mounting evidence suggesting that structured physical activity may serve as a promising therapeutic intervention. The intricate interplay between physical activity, inflammatory markers, gut microbiota composition, and disease activity represents a crucial area of

investigation, particularly given the current limitations of conventional pharmacological approaches in achieving sustained disease control.

This study seeks to elucidate the multifaceted relationship between varying levels of physical activity and three key parameters in IBD patients:

- The modulation of inflammatory markers and their associated molecular pathways
- Alterations in gut microbiota composition and diversity
- Clinical disease activity indices and patient-reported outcomes.

The investigation also addresses how different intensities and modalities of physical activity influence these parameters, considering both acute and chronic adaptations.

The study aims to:

1. Elucidate the molecular mechanisms underlying the exercise-inflammation axis in IBD, with particular emphasis on:
- The cascade of anti-inflammatory cytokines induced by muscular activity
- Oxidative stress biomarkers and their relationship to disease activity
- Pro-inflammatory cytokine profiles and their modulation through exercise.

2. Investigate the complex interactions between physical activity and gut microbiota by:
- Analyzing changes in microbial diversity and composition
- Evaluating the functional implications of exercise-induced microbiota modifications
- Assessing the relationship between microbiota alterations and disease outcomes.

3. Conduct a comprehensive evaluation of how various physical activity intensity levels impact:
- Disease activity indices and clinical remission rates
- Quality of life metrics and functional capacity measures
- Muscle strength and aerobic capacity parameters
- Fatigue levels and physical activity patterns.

4. Develop evidence-based recommendations for:
- Optimal exercise protocols considering disease severity
- Safety parameters and contraindications
- Integration of physical activity into standard IBD management protocols

- Strategies to improve long-term adherence to exercise programs.

This research aims to contribute to the development of personalized exercise prescriptions for IBD patients, potentially establishing physical activity as a viable adjunctive therapy in the comprehensive management of inflammatory bowel disease.

2. Materials and methods

2.1 Search strategy

A comprehensive literature search was conducted using databases such as PubMed, Scopus, Web of Science, Cochrane and Embase to identify relevant studies and reviews. The search focused on key terms, including "inflammatory bowel disease," "Crohn's disease," "ulcerative colitis," "physical activity," "exercise," "inflammatory markers," "gut microbiota," and "disease activity." The search was limited to publications from 2010 to 2024. Bibliographies of selected articles and manual searches in specialized journals were also included.

2.2 Inclusion criteria

Studies were included if they met the following criteria:

1. Peer-reviewed original research, systematic reviews, or meta-analyses
2. Focused on physical activity or exercise interventions in IBD patients
3. Examined relationships between exercise and gut microbiota
4. Reported outcomes related to disease activity, quality of life, or microbiome composition in IBD patients.

2.3 Exclusion criteria

Publications were excluded if they were:

1. Conference abstracts
2. Case reports
3. Studies without clear methodological documentation
4. Articles not published in English

5. Articles that focused on other inflammatory or autoimmune diseases unrelated to IBD
6. Articles published before 2010 were excluded unless they provided a significant historical context relevant to the research topic.

2.4 Evaluation process

The quality of the identified sources included evaluating the methodological rigour to ensure systematic research methods. Priority was given to randomized controlled trials, longitudinal cohort studies, and systematic reviews with meta-analyses. In addition, the clarity of the results was examined to confirm that the conclusions were well supported by the data.

3. State of knowledge

3.1 Inflammatory Bowel Disease

Crohn's disease (CD) and ulcerative colitis (UC), collectively classified as inflammatory bowel disease (IBD), are chronic inflammatory disorders of the gastrointestinal tract that can lead to cachexia. They result from a complex interaction of host genetic factors, gut microbiota and environmental influences (Swaminathan et al. 2024).

UC is a chronic condition of unknown cause that involves diffuse inflammation of the colonic mucosa, starting from the rectum and progressing proximally. The disease leads to erosions and ulcerations as a result of continued damage to the mucosa. CD is a chronic, multilayered inflammatory disease of undetermined etiology, characterized by segmental involvement of the gastrointestinal tract. It can involve any part of it, from the mouth to the anus. Granulomatous lesions, fistulas and inflammation involving the full thickness of the intestinal wall are characteristic (Nakase et al. 2021).

IBD is characterized by a varied, often recurrent and relapsing clinical course. Typical symptoms include diarrhea, abdominal pain, rectal bleeding, stool pushing, fecal incontinence and fatigue. In addition, anemia, perianal fistulas, increased risk of colorectal cancer and bowel failure may occur. These diseases have a significant impact on patients' quality of life and require individually tailored treatment (Swaminathan et al. 2024).

Patients with IBD have a slightly higher risk of cerebrovascular incidents, ischemic heart disease, mesenteric ischemia, atrial fibrillation and heart failure, regardless of therapy. In

IBD, the most common types of anemia are iron deficiency and anemia associated with chronic diseases. Skin diseases, such as pyoderma gangrenosum, Sweet's syndrome, erythema nodosum, oral lesions, inflammation of the sweat glands and psoriasis, are among the most common extraocular manifestations of IBD. In addition, ocular manifestations, especially anterior uveitis, are quite common in this group of patients. Neurological symptoms, such as venous sinus thrombosis, stroke or central nervous system demyelination, may be more common in IBD patients than in the general population (Gordon et al. 2024).

The global age-standardized incidence rate of inflammatory bowel disease (ASIR) increased from 4.22 per 100,000 people in 1990 to 4.45 per 100,000 in 2021. At the same time, an increase in the global incidence of IBD was observed between 1990 and 2021, with a decrease in DALY and mortality rates (Lin et al. 2024). The incidence of inflammatory bowel disease peaks in the third decade of life, then stabilizes between the fourth and eighth decades and gradually declines thereafter (Lewis et al. 2023).

The care of patients with IBD aims to reduce morbidity, improve quality of life and prevent intestinal damage. Recurrent disease activity in CD leads to strictures, fistulas and penetrating complications, and in UC to fibrosis and an increased risk of colorectal cancer and the need for colectomy. Early onset (<40 years) in both diseases is associated with poorer treatment outcomes, more frequent recurrences, the need for anti-TNF therapy and a higher risk of colectomy and cancer (Swaminathan et al. 2024).

3.2 The effect of physical activity on markers of inflammation.

Emerging research highlights the multifaceted effects of physical activity on inflammatory markers and intestinal microbiota composition in individuals with inflammatory bowel disease (IBD). A recent study demonstrated that moderate-intensity physical activity significantly reduced C-reactive protein (CRP) levels, a key systemic marker of inflammation, while also decreasing pro-inflammatory cytokines such as IL-6 and TNF-α. This study identified that consistent periods of exercise at moderate intensity, such as 30 minutes of aerobic activity five times per week, led to reductions in these biomarkers. CRP levels were found to decline by up to 20% with this regimen, while IL-6 and TNF-α followed a similar downward trend. However, this study primarily focused on systemic markers of inflammation, with less emphasis on localized gut markers such as fecal calprotectin. (Hill et al. 2023).

Evidence further suggests that low-to-moderate intensity physical activity has positive effects on both IL-6 and fecal calprotectin levels in IBD patients. Regular activity, such as walking or gentle aerobic workouts, is associated with reductions in IL-6 by approximately 10–15%, while fecal calprotectin levels were observed to decline by a similar margin. In contrast, high-intensity regimens like competitive running or strenuous weightlifting failed to show the same reduction in markers. Instead, these higher-intensity exercises have sometimes been associated with heightened inflammation or immune stress in vulnerable individuals. This demonstrates that the intensity of physical activity must be carefully matched to the individual's condition to achieve anti-inflammatory effects without exacerbating disease activity (Oketola et al. 2023).

Furthermore, studies exploring the role of physical activity on gut microbiota composition highlight that moderate-intensity exercise promotes beneficial microbial diversity linked to improved gut health. Specifically, regular, moderate aerobic activity was associated with an increased relative abundance of anti-inflammatory bacteria, such as Faecalibacterium prausnitzii and Bifidobacterium species. These bacteria are well-established for their roles in promoting gut health by regulating inflammation. Changes in microbiota composition correlated with lower pro-inflammatory cytokine levels such as TNF-α and IL-6, though the exact causal mechanisms remain to be fully elucidated. These observations indicate that changes in gut bacteria linked to exercise may represent an important pathway by which physical activity can exert its immunomodulatory effects in IBD (Oketola et al. 2023).

Collectively, the studies suggest that low-to-moderate intensity physical activity holds promise for reducing systemic and localized inflammation in IBD by lowering CRP, IL-6, TNF-α, and fecal calprotectin levels (Hill et al.2023, Oketola et al. 2023). Fecal calprotectin is particularly useful in differentiating between irritable bowel syndrome (IBS) and organic gastrointestinal disorders, including IBD. Fecal calprotectin levels are significantly higher in UC patients compared to healthy controls. Fecal calprotectin is a more precise diagnostic marker compared to traditional inflammatory biomarkers, such as C-reactive protein (CRP) or the passerine reaction (ESR) (Khaki-Khatibi et al. 2020).

Additionally, physical activity has been shown to positively influence gut microbiota composition, notably by increasing anti-inflammatory bacterial species that correlate with reductions in cytokines like TNF-α and IL-6. These effects are dose-dependent, with moderate exercise demonstrating a beneficial balance, while excessive physical stress through high-

intensity exercise may hinder these effects and lead to pro-inflammatory responses. However, further longitudinal studies with larger sample sizes are needed to refine these findings and establish optimal exercise regimens for IBD patients. (Hill et al.2023, Oketola et al. 2023).

3.3 The effect of physical activity on the gut microbiota

3.3.1 Microbial Diversity

Low-intensity exercise appears to have a limited but positive impact on gut microbiota diversity. Even breaking sedentary behavior can lead to improvements in microbial diversity (Varghese et al. 2024). This suggests that any level of physical activity may be beneficial for gut health.

Medium to high-intensity exercise demonstrates more pronounced effects on microbial diversity. Studies indicate that individuals engaging in moderate to high-intensity exercise for 30–90 minutes, at least three times per week (or between 150–270 minutes per week), for a minimum of 8 weeks, are likely to experience significant changes in their gut microbiota (Boytar et al. 2023).

Athletes and highly active individuals consistently show higher microbial diversity compared to sedentary controls (Boytar et al 2023, Clauss et al. 2021) This increased diversity is associated with better health outcomes and may contribute to the overall health benefits observed in physically active populations.

Interestingly, the relationship between exercise intensity and microbial diversity appears to be dose-dependent (Boytar et al 2023). Vigorous exercise may elicit greater changes in the human gut microbiota compared to lower-intensity exercise. However, it's important to note that extremely high-intensity exercise, especially when prolonged, can potentially lead to negative effects such as increased gut permeability (Clauss et al. 2021).

The observed increases in microbial diversity with exercise are often accompanied by shifts in the abundance of specific bacterial taxa. For instance, exercise has been associated with increases in health-promoting bacteria such as those involved in the production of short-chain fatty acids (Ghaffar et al. 2024, Clauss et al. 2021).

3.3.2 Bacterial Composition

The impact of physical activity on gut bacterial composition varies with exercise intensity, as evidenced by several studies.

Firmicutes/Bacteroidetes Ratio: exercise generally increases the relative abundance of Firmicutes and decreases Bacteroidetes, with more pronounced shifts observed in higher intensity exercise. High-intensity interval training led to a significant increase in the Firmicutes/Bacteroidetes ratio compared to moderate continuous training (Ghaffar et al. 2024).

Beneficial Bacteria: active individuals show higher abundance of health-promoting bacteria: Faecalibacterium prausnitzii, which are increased in individuals engaging in regular moderate to high-intensity exercise. Higher levels of Roseburia hominis were found in active individuals, particularly those participating in endurance activities (Petri et al. 2024). Akkermansia muciniphila were significantly elevated in athletes and individuals engaging in high-intensity exercise regimens (Ghaffar et al 2024, Aya et al.2023).

Athlete-Specific Changes: high-level athletes exhibit distinctive microbial profiles in their gut microbiota. Studies have shown an increased abundance of Akkermansia muciniphila in athletes, which is associated with improved metabolic health (Ghaffar et al 2024, Aya et al.2023). Additionally, marathon runners demonstrate higher levels of Veillonella, a bacteria capable of utilizing lactate (Scheiman et al. 2019).

Exercise Intensity-Dependent Changes: low-intensity exercise induces modest changes, primarily characterized by slight increases in short-chain fatty acid (SCFA)-producing bacteria (Boytar et al. 2023). As exercise intensity increases to moderate levels, more pronounced shifts occur, including increases in beneficial bacteria such as Faecalibacterium and Roseburia (Marttinen et al. 2020). High-intensity exercise elicits the most significant alterations in gut microbiota, with notable increases in Akkermansia and athlete-specific bacteria like Veillonella (Marttinen et al. 2020, Scheiman et al. 2019, Torquati et al. 2023).

These findings suggest that the type and intensity of physical activity play crucial roles in shaping the composition of the gut microbiome, with potential implications for overall health and athletic performance.

3.3.3. Metabolites

Physical activity significantly influences bacterial metabolites in the gut microbiota, with effects varying based on exercise intensity. Exercise is associated with increased short-

chain fatty acid (SCFA)-producing bacteria, particularly butyrate-producing species (Barzak et al. 2022, Petri et al. 2024). Both moderate-intensity continuous training and high-intensity interval training affect gut microbiome composition, though their impact on fecal SCFA concentrations may not differ significantly (Cullen et al. 2023). High-intensity exercise, especially in elite athletes, is associated with higher levels of Veillonella, a lactate-utilizing bacteria (Petri et al. 2024, Sales and Reimer 2022).

Exercise also influences other metabolic pathways, including pyruvate metabolism and cell wall membrane envelope biogenesis (Cullen et al. 2024). Physical activity increases the availability of substrates for bacterial fermentation due to changes in intestinal transit time (Ghaffar et al. 2024, Barzak et al. 2022). However, the relationship between exercise intensity and gut bacterial metabolites is complex and influenced by factors such as diet, baseline fitness level, and individual microbiome composition (Cullen et al. 2023, Barzak et al. 2022).

Studies have shown that moderate exercise promotes a healthy immune system, while high-intensity exercise for long durations may cause gut permeability and systemic inflammation, potentially disrupting microbial balance (Ghaffar et al. 2024, Barzak et al. 2022). Combining aerobic and resistance training significantly affects bacterial diversity, linked to a lower prevalence of chronic metabolic disorders (Petri et al. 2024, Cullen et al. 2023). Exercise enhances gut microbiome diversity, increases SCFA production, improves nutrient utilization, and modulates neural and hormonal pathways, improving gut barrier integrity (Petri et al. 2024, Alruways MW 2023, Barzak et al. 2022) . Further research is needed to fully elucidate the mechanisms behind these exercise-induced changes and their long-term health implications (Sales KM and Reimer RA 2023, Cullen et al. 2023)

3.3.4 Intestinal Barrier Integrity

Regular exercise has been shown to strengthen the intestinal barrier through various mechanisms. Endurance exercise capacity indirectly enhances intestinal barrier function, as evidenced by a study that indicated improvements in gut barrier integrity biomarkers in individuals engaging in regular physical activity, particularly in endurance athletes who often experience gastrointestinal disturbances due to the physiological demands of their training (Schmitz et al. 2019).

Additionally, regular physical activity contributes to an increased abundance of mucin-degrading bacteria, particularly Akkermansia muciniphila. This bacterium not only utilizes

mucin as a nutrient source but also promotes the production of mucin by enhancing goblet cell density, thereby thickening the mucus layer and reinforcing the intestinal barrier (Mo C et al. 2024). A. muciniphila has been shown to upregulate tight junction proteins such as zonulin and occludin, which are crucial for maintaining the integrity of the gut epithelium (Hintikka et al. 2023). Furthermore, A. muciniphila produces short-chain fatty acids (SCFAs) during mucin fermentation, which further supports intestinal health by reducing inflammation and improving barrier function (Min L et al. 2024).

These findings collectively suggest that regular endurance exercise positively impacts intestinal barrier integrity through both physiological adaptations and beneficial modulation of gut microbiota composition, particularly involving A. muciniphila (Chelakkot et al. 2018).

3.3.5 Mechanisms of Microbiota Modulation

Exercise modulates the gut microbiota through several mechanisms, significantly impacting microbial composition and overall gut health. One key mechanism is the reduction of stool transit time associated with low-intensity exercise, which can lead to changes in microbial populations by allowing beneficial bacteria more time to ferment substrates in the gut. This alteration in transit time enhances the growth of specific bacterial taxa that promote gut health, effectively reducing the risk of gastrointestinal diseases such as colon cancer and inflammatory bowel disease (Ghaffar et al. 2024).

Additionally, exercise-induced stress responses can influence gut microbiota composition; physical activity may induce hormonal and metabolic changes that affect microbial diversity and abundance. Recent evidence suggests a high correlation between physical and emotional stress during exercise and changes in gastrointestinal microbiota composition, highlighting the complex interplay between stress and microbial balance (Clark A and Mach N 2016).

Furthermore, exercise affects host metabolism, indirectly influencing the gut environment by enhancing energy availability and altering nutrient absorption. This metabolic shift promotes the growth of beneficial bacteria and increases the production of short-chain

fatty acids (SCFAs), which are crucial for maintaining gut barrier integrity and overall health (Clauss et al. 2021). Collectively, these mechanisms highlight how different intensities of physical activity can shape the gut microbiome, leading to potential health benefits.

3.3.6 Clinical Significance

The observed changes in gut microbiota due to physical activity have significant clinical implications, particularly concerning Inflammatory Bowel Disease (IBD).

Exercise-induced alterations in gut microbiota composition may contribute to chronic disease prevention, as regular physical activity has been linked to improved gut health and reduced inflammation. Research indicates that physical exercise is a modulator of the intestinal microbiome, causing shifts in its composition that are partially corrective of those observed in IBD. Furthermore, physical exercise may be beneficial in patients with certain IBD subtypes, enhancing microbial diversity and promoting the growth of beneficial bacteria that play a crucial role in maintaining gut homeostasis and preventing disease flares in IBD patients (Mc Gettingan et al. 2022).

Moreover, changes in microbial composition are associated with improvements in metabolic markers, such as reduced levels of pro-inflammatory cytokines and enhanced mucosal barrier function. These improvements can lead to better management of IBD symptoms and a lower risk of complications, thereby improving the overall quality of life for patients (Koutouratsas et al. 2021).

Additionally, alterations in gut microbiota may influence the gut-brain axis, potentially affecting mental health in individuals with IBD. The bidirectional relationship between physical activity and the gut microbiome suggests that exercise can promote beneficial bacteria while a healthy gut microbiome can potentially enhance exercise ability through various mechanisms (Mc Gettingan et al. 2022). Studies indicate that a healthy diversity in gut microbiota can help manage stress, anxiety, and even depression, demonstrating this profound gut-brain connection (Koutouratsas et al. 2021).

Collectively, these findings underscore the importance of physical activity not only for physical health but also for metabolic and mental well-being in patients with Inflammatory Bowel Disease.

4. Effect of physical activity on disease activity

4.1 Exacerbation Rate

Physical activity has been shown to reduce the risk of disease exacerbations in patients with IBD. Jones et al. (2015) conducted a prospective study examining the association between exercise and future disease activity in patients with Crohn's disease (CD) and ulcerative colitis (UC) in remission. They found that higher levels of physical activity significantly decreased the risk of active disease at six months for CD (adjusted risk ratio [RR]: 0.72; 95% CI: 0.55–0.94). A similar trend was observed for UC, though it was not statistically significant (adjusted RR: 0.78; 95% CI: 0.54–1.13) (Jones et al. 2015). This suggests that regular exercise may help maintain remission and reduce the frequency of disease flares.

4.2 Severity of Clinical Symptoms

Moderate physical activity has been associated with improvements in clinical symptoms and quality of life among IBD patients. Klare et al. (2015) conducted a randomized controlled trial where participants engaged in a 10-week moderate-intensity running program. They observed significant improvements in health-related quality of life (HRQOL), particularly in the social subscale of the Inflammatory Bowel Disease Questionnaire (IBDQ). This indicates that regular physical activity can alleviate some of the psychological and social burdens associated with IBD (Klare et al. 2015).

4.3 Disease Activity Indices (CDAI, Mayo Score)

The impact of physical activity on disease activity indices such as the Crohn's Disease Activity Index (CDAI) and Rachmilewitz Index (RI) has been explored in several studies:

Klare et al. (2015) reported no significant changes in CDAI or RI scores after a 10-week exercise program, suggesting that moderate-intensity exercise does not exacerbate disease activity.

Jones et al. (2015) used the short CDAI (sCDAI) and Simple Clinical Colitis Activity Index (SCCAI) to assess disease activity after six months. They found that higher exercise levels were associated with a lower risk of active disease, as measured by these indices.

4.4 Length of Remission Periods

Regular physical activity may contribute to maintaining longer remission periods in IBD patients. Jones et al. (2015) demonstrated that higher levels of exercise were associated with a reduced likelihood of transitioning from remission to active disease over six months. This finding highlights the potential role of exercise in sustaining remission.

4.5 Psychophysical aspects

Physical activity has emerged as a key non-pharmacological intervention with the potential to improve multiple psychophysical aspects of life for individuals with inflammatory bowel disease (IBD). Regular exercise contributes significantly to enhancing overall quality of life by fostering resilience to disease exacerbations, increasing energy levels, and alleviating feelings of isolation, which are commonly reported in chronic conditions like IBD (Oketola et al. 2023, Davis et al. 2021).

Moreover, physical activity has demonstrated profound benefits for mental health, particularly in reducing symptoms of depression and anxiety. These psychological improvements are believed to result from reduced systemic inflammation and enhanced gut-brain axis communication, which are critical in regulating mood and stress levels (Oketola et al. 2023, Abegunde et al. 2023). Fatigue, a debilitating and persistent symptom of IBD, can be effectively managed through tailored exercise programs that improve cardiovascular health, muscular strength, and energy metabolism.

Studies have shown that engaging in regular physical activity stimulates endorphin release and decreases inflammatory markers, contributing to sustained improvements in physical performance and overall vitality (Oketola et al. 2023, Tiong et al. 2024).

Additionally, extraintestinal symptoms such as joint pain, skin conditions, and ocular inflammation - which often complicate the clinical presentation of IBD are mitigated by the anti-inflammatory effects of moderate-intensity exercises like swimming and yoga. These activities not only enhance joint mobility but also support immune regulation and gut microbiota diversity, both of which are linked to symptom relief (Oketola et al. 2023, Davis et al. 2022).

Chronic pain, another challenging aspect of IBD, can be alleviated through structured physical activity that reduces visceral hypersensitivity and promotes muscular relaxation. The release of endogenous opioids during exercise further helps to manage pain without the need for increased reliance on pharmacological agents (Tiong et al. 2024, Oketola et al. 2023, Abegunde et al. 2023).

Collectively, these findings underscore the critical role of physical activity in addressing the intertwined physical and psychological challenges faced by IBD patients, emphasizing the importance of personalized exercise regimens tailored to individual needs.

5. Identifying Barriers to Undertaking Physical Activity in Patients with IBD

Despite the potential benefits of physical activity in reducing inflammation and improving overall quality of life, many patients with IBD encounter significant barriers to regular exercise. These barriers can be categorized into physical limitations, psychological barriers, social factors, and concerns about health deterioration.

5.1 Physical Limitations of Activity

A prominent barrier to physical activity in IBD patients is the presence of physical symptoms such as fatigue, joint pain, and gastrointestinal discomfort. Fatigue, which affects up to 54% of patients, is one of the most cited reasons for decreased physical activity post-diagnosis (Lukose et al., 2022). A cross-sectional study in New Zealand found that lower adherence to recommended physical activity levels correlated with increased fatigue and reduced quality of life (Fagan et al. 2021). These physical symptoms not only impact energy levels but also reduce the motivation and physical capacity to engage in consistent exercise.

Furthermore, disease-specific factors, including the unpredictability of flare-ups and gastrointestinal symptoms like diarrhea, can impede regular exercise routines (Tew et al., 2016).

These findings underscore the importance of creating personalized exercise plans that accommodate physical limitations and address the unique needs of IBD patients.

5.2 Psychological Barriers

Psychological factors, including body image concerns, anxiety, and depression, play a significant role in limiting physical activity among IBD patients. The Irish multi-centre study by Gettingan et al. (2022) highlighted that body image issues are particularly prevalent among women and younger patients, contributing to a decline in exercise participation post-diagnosis. Anxiety and depression, often associated with chronic illness, further discourage engagement in physical activity (Olive et al., 2020). Psychological distress has been linked to lower physical activity levels, reinforcing the need for integrated mental health support within physical activity programs (Fagan et al. 2021).

A qualitative study by Jones et al. (2023) found that lack of motivation and psychological burnout are common barriers, particularly when patients face a lack of perceived improvement or fear of symptom exacerbation. Structured exercise programs that incorporate psychological counseling and motivation strategies can help overcome these barriers and promote adherence to physical activity.

5.3 Social Barriers

Social factors, such as lack of support, stigma, and logistical challenges, significantly impact physical activity engagement in IBD patients. Tew et al. (2016) identified the importance of community support and flexible exercise options in overcoming these barriers. Stigma associated with chronic illness and the visibility of symptoms can deter patients from participating in group activities or using public exercise facilities (Fourie et al., 2018). Women, in particular, report a higher emotional toll and lack of social support, which limits their ability to maintain active lifestyles (Sykes and Fletcher, 2015).

Work-life balance and time constraints are additional social barriers, especially for individuals balancing employment, family responsibilities, and disease management (Jones et al., 2023). Tailored interventions that offer group-based or community-oriented exercise

programs, along with digital or home-based exercise options, can help mitigate these social challenges and foster a supportive environment for physical activity (Neal et al., 2022).

5.4 Concerns About Deterioration of Health

Many patients with IBD harbor concerns that physical activity may exacerbate their condition or trigger flare-ups. These fears are not unfounded, as the unpredictable nature of IBD symptoms can make exercise seem risky. Studies have shown that patients with active or moderately active disease often avoid exercise due to fear of worsening symptoms (Oketola et al., 2023). Jones et al. (2022) noted that patients perceive high-intensity exercise as potentially harmful, advocating for the inclusion of low-impact and moderate-intensity activities in exercise recommendations. Moreover, patients frequently lack guidance on safe exercise practices specific to their condition (Bilski et al., 2014).

Physician-guided exercise programs and education about the anti-inflammatory benefits of regular exercise can help alleviate these concerns and build patient confidence. Structured interventions that gradually increase exercise intensity and are responsive to symptom fluctuations can reduce the fear of health deterioration (Jones et al., 2022)

6. Guidelines for Implementing Physical Activity in IBD Therapy

6.1 Optimal Forms of Physical Activity:

- **Aerobic Activity**

The most substantial benefits for IBD patients come from regular, moderate-intensity aerobic exercise, which positively influences gut microbiota. Research shows that such activity enhances microbiota diversity, fostering the growth of anti-inflammatory bacteria such as *Faecalibacterium prausnitzii*. Additionally, it increases the production of butyrate, a critical metabolite for maintaining intestinal barrier integrity and reducing inflammation (Cataldi et al. 2022).

- **Resistance Training**

Resistance training offers additional benefits, including improved muscle strength, endurance, and overall physical fitness. Low-intensity resistance exercises are particularly recommended

for patients in remission, as they support recovery without exacerbating symptoms (Al-Nimer MS 2024).

- **Combined Training**

An effective alternative is combined training, which integrates both aerobic and resistance components. This approach enhances metabolic health, immune function, and overall quality of life, particularly during remission phases (Oketola et al. 2023).

6.2 Impact on Mental Health

In addition to physiological benefits, PA plays a crucial role in reducing stress, improving mood, and enhancing sleep quality in IBD patients. Studies highlight its effectiveness in alleviating symptoms of depression and anxiety, which are common comorbidities in IBD (Cohen DL and Shirin H 2021).

6.3 Intensity and Frequency of Exercise

Studies emphasize the importance of moderate-intensity PA, defined as 50–70% of maximum heart rate (HRmax). Exercise within this range induces beneficial changes in the gut microbiota and immune system while minimizing the risk of overburdening the body. The optimal frequency is 3–5 sessions per week, with each session lasting 30–45 minutes (Rasmussen et al. 2021).

High-intensity exercise should be avoided, particularly during disease flare-ups, as it may exacerbate immune responses and inflammatory symptoms. Adjusting exercise intensity to the patient's condition is critical for safety and efficacy (Gatt et al. 2019).

6.4 Modifications to Exercise Programs Based on Disease Status

- **Patients in Remission**

During remission, more diverse programs are recommended, encompassing aerobic, resistance, and combined exercises. These programs support remission stabilization, enhance metabolic functions, and increase gut microbiota diversity. Incorporating relaxation techniques, such as yoga, can further help reduce stress levels (Cataldi et al. 2022).

- **Patients in Flare-Up Phases**

During flare-ups, PA should be limited to gentle forms such as walking, yoga, or breathing exercises. This approach supports recovery while reducing the risk of physical strain and symptom aggravation (Rasmussen et al. 2021). Monitoring exercise tolerance during this phase is essential for patient safety.

6.5 Monitoring Safety and Effectiveness

Effective implementation of PA requires continuous monitoring of patients' health status. Key components of supervision include:

- **Assessment of Inflammatory Markers**: Regular laboratory tests (e.g., CRP, calprotectin) can help monitor the impact of exercise on disease activity (Zittermann et al. 2021).
- **Symptom Tracking**: Patients should report changes in symptoms and well-being during and after exercise sessions (Pedersen BK and Saltin B 2015).
- **Gradual Progression**: Exercise intensity and load should be gradually increased based on the body's response (Oketola et al. 2023).

6.6 Strategies for Implementing Exercise Programs

Successful implementation of PA programs necessitates an integrated and interdisciplinary approach:

- **Patient Education**: Educating patients about the benefits of PA and training them to self-monitor exercise tolerance is vital (Lichtenstein et al. 2018).

- **Interdisciplinary Collaboration**: Designing exercise programs should involve physicians, physiotherapists, and dietitians to ensure individualized therapy (Oketola et al. 2023).
- **Group Support**: Organizing group sessions for IBD patients can boost motivation and provide social support, increasing the likelihood of long-term adherence (Oketola et al. 2023).

7. Challenges and future directions

The relationship between physical activity, inflammatory markers, intestinal microbiota composition, and disease activity in inflammatory bowel disease (IBD) presents intricate challenges and prospects for advancement. The diversity of the gut microbiota, influenced by genetic, dietary, and environmental factors, complicates the determination of how exercise impacts these systems. Cross-sectional study designs often dominate existing research, limiting the ability to draw causal conclusions and emphasizing the importance of longitudinal approaches to understand temporal dynamics (Demers et al. 2023).

Additionally, the variability in exercise type, duration, and intensity introduces complexities in creating universally applicable recommendations, as individual outcomes are shaped by factors such as disease severity, medications, and coexisting conditions. Future investigations should adopt longitudinal and multicenter methodologies to account for temporal changes and ensure the inclusion of diverse population groups. Incorporating cutting-edge omics techniques like metagenomics and metabolomics could uncover the underlying biological mechanisms linking physical activity to changes in the microbiota and inflammatory processes (Khalil et al. 2024, Demers et al. 2023).

Personalized exercise regimens, designed based on individual microbiota profiles and disease characteristics, have the potential to improve therapeutic effectiveness. Further research into the mechanistic effects of exercise, including its impact on gut barrier integrity and the production of microbial metabolites, is crucial. Finally, integrating physical activity with dietary adjustments and medical treatments may offer a synergistic approach, paving the way for comprehensive and effective disease management strategies (Ahmad et al. 2023).

8.Conclusions

8.1 Key Findings

Physical activity demonstrates significant therapeutic potential in IBD management through multiple mechanisms. Moderate-intensity exercise reduces inflammatory markers like CRP and pro-inflammatory cytokines by 10-20%, while promoting beneficial changes in gut microbiota composition. Regular physical activity enhances microbial diversity and increases the abundance of anti-inflammatory bacteria, particularly Faecalibacterium prausnitzii and Akkermansia muciniphila. Physical activity, particularly at moderate intensity, appears to offer multiple benefits for IBD patients, including reduced exacerbation rates, improved quality of life, and potential maintenance of remission periods.

8.2 Research Gaps

Several critical areas require further investigation. The exact mechanisms linking exercise intensity to microbiota modulation remain incompletely understood. Additionally, longitudinal studies with larger cohorts are needed to establish optimal exercise protocols for different IBD phenotypes and disease states. The interaction between physical activity and conventional IBD therapies also warrants deeper exploration.

8.3 Implications for Clinical Practice

The findings support incorporating structured physical activity into standard IBD management protocols. Moderate-intensity exercise, particularly 30-45 minutes 3-5 times weekly, appears most beneficial for maintaining remission and improving quality of life. However, exercise prescriptions must be personalized, considering disease severity, current symptoms, and individual fitness levels.

8.4 Future Directions

Research should prioritize:

- Longitudinal studies examining long-term effects of exercise on IBD outcomes
- Integration of advanced omics technologies to understand mechanistic pathways
- Development of personalized exercise protocols based on individual microbiota profiles
- Investigation of synergistic effects between physical activity and conventional treatments.

8.5 Final Thought

This research establishes physical activity as a promising therapeutic tool in IBD management, highlighting its potential to modulate inflammatory responses, enhance gut microbiota composition, and improve clinical outcomes. The findings provide a foundation for developing evidence-based exercise guidelines while identifying crucial areas for future investigation to optimize IBD care through physical activity interventions.

Authors' Contributions Statement:

- Conceptualization: Paulina Jakubczyk
- Data Curation: Paulina Jakubczyk, Aleksandra Buczek, Wiktoria Janik, Marta Handschuh, Justyna Helis, Piotr Widera, Aleksandra Banaś, Maciej Michalik, Hubert Bigajski
- Formal Analysis: Paulina Jakubczyk, Aleksandra Buczek, Olga Bilczewska, Wiktoria Janik, Marta Handschuh, Justyna Helis, Piotr Widera, Aleksandra Banaś
- Investigation: Paulina Jakubczyk, Aleksandra Buczek, Olga Bilczewska, Wiktoria Janik, Marta Handschuh, Justyna Helis, Maciej Michalik, Hubert Bigajski
- Methodology: Paulina Jakubczyk, Maciej Michalik, Piotr Widera
- Project Administration: Paulina Jakubczyk, Wiktoria Janik, , Hubert Bigajski
- Resources: Hubert Bigajski, Wiktoria Janik, Piotr Widera, Justyna Helis
- Software: Olga Bilczewska, Aleksandra Banaś, Marta Handschuh, Piotr Widera
- Supervision: Paulina Jakubczyk, Marta Handschuh, Hubert Bigajski

- Validation: Aleksandra Buczek, Paulina Jakubczyk , Olga Bilczewska, Wiktoria Janik, Marta Handschuh, Justyna Helis, Piotr Widera, Aleksandra Banaś, Maciej Michalik, Hubert Bigajski
- Visualization: Aleksandra Buczek, Paulina Jakubczyk, Olga Bilczewska, Marta Handschuh, Justyna Helis, Piotr Widera, Aleksandra Banaś, Maciej Michalik, Hubert Bigajski
- Writing – Original Draft: Paulina Jakubczyk, Hubert Bigajski, Aleksandra Buczek, Olga Bilczewska, Wiktoria Janik, Marta Handschuh
- Writing – Review & Editing: Justyna Helis, Piotr Widera, Aleksandra Banaś, Maciej Michalik, Hubert Bigajski

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