

**Physical Activity for Individuals with Quiescent or Mildly Active Inflammatory
Bowel Disease (IBD)**

By

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A Thesis submitted to the Faculty of Graduate Studies and Postdoctoral Studies of the
University of Manitoba

In partial fulfillment of the requirements of the degree of
DOCTOR OF PHILOSOPHY

Applied Health Sciences

University of Manitoba.

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Abstract

Physical activity (PA), including the sub-category of exercise, is widely used as an adjunct therapy in several chronic conditions including Inflammatory Bowel Disease (IBD). However, individuals with IBD do not regularly perform enough PA to gain its benefits. This thesis aimed to address this problem by investigating the safety and efficacy of PA in IBD, explore barriers to PA participation, and develop an IBD-specific PA program.

The objectives of this research program were fulfilled via three linked studies. The first study involved a systematic review of trials on PA as adjunct therapy to reduce persistent IBD symptoms and improve health-related quality of life. Next, a qualitative description study was conducted to explore the barriers and facilitators of PA participation, including patient-centred strategies to enhance participation among adults ages 20 – 45 years with quiescent or mildly active IBD. Using the findings from the first and second studies, an IBD-specific, personalized, application-based PA program was developed. The acceptability and feasibility of this program was investigated in a 12-week pilot non-randomized trial.

The results of the three studies are presented in this manuscript-style thesis. Findings of the systematic review indicated that the available trials show considerable heterogeneity on PA in IBD. However, relevant activities and exercises deemed safe for adults with IBD were identified (chapter 2). The qualitative study suggested relevant behaviour change strategies and facilitators necessary to promote PA engagement (chapters 3 and 4). Based on the findings of these two studies, a three-pronged intervention consisting of a) PA program, specifically progressive aerobic, resistance and flexibility exercises; b) behaviour change strategies (including social support, prompts, feedback); and c) knowledge on PA and IBD shared via posters and infographics, was developed. The intervention, ‘Active for IBD’, delivered via a cell

phone application, was found to be acceptable by 80% of participants and 81% of feasibility indicators were achieved (chapter 5).

Regular engagement in PA by individuals unfamiliar with doing so requires a complex behaviour change. In the IBD population, this can be even more challenging compared to those without IBD. The novel IBD-specific intervention developed in this thesis may help enhance engagement.

Acknowledgements

This dissertation represents the culmination of years of learning and growth. Completing this doctoral journey has been made possible through the guidance, encouragement and generosity of a few significant individuals. I owe immense gratitude to my co-supervisors, Dr. Sandra Webber and Dr. Harminder Singh; extraordinary mentors whose intellectual generosity, patience and unwavering support shaped every stage of this work. Their thoughtful feedback, high standards and belief not only in my vision for this dissertation but also in my abilities, challenged me to grow as a scholar and strengthened the quality of this dissertation. I am deeply thankful for the time, care, and confidence they invested in me.

I owe deep gratitude to my committee members, Dr. Gayle Restall, Dr. Kristin Reynolds and Dr. Maia Kredentser, for their time, insights, and constructive critiques. Their diverse perspectives enriched my thinking and pushed this project in more rigorous and meaningful directions. Their questions pushed me to think more critically, their feedback sharpened my arguments, and their support reminded me that this project mattered. I appreciate the care with which they engaged my work and the encouragement they offered throughout the process.

I gratefully acknowledge the studentship from the Canadian Association of Gastroenterology, the research grant from Pfizer, the first-year tuition support provided through Dr. Harminder Singh, the Faculty of Graduate and Postdoctoral Studies scholarships provided through Dr. Sandra Webber, and the travel grants awarded through the Section of Gastroenterology and the research grants awarded through the Applied Health Sciences program. These funding supports played a critical role in enabling the research activities and scholarly dissemination that underpin this dissertation.

To my parents, thank you for your countless sacrifices, the quiet encouragement and the steady love that carried me through every stage of this work. You taught me to work hard and to reach for my goals. And every time I reached, you supported me in every way I needed. This dissertation is a reflection of the faith you have always had in me. I am endlessly grateful. To my sisters and brothers-in-law, your support has been nothing short of extraordinary. You carried me through this process with your kindness and your financial, psychological and emotional support. You all made sure I never felt alone in this journey, even when the work felt overwhelming. I am profoundly grateful for your love, your sacrifices and your steady presence.

To my daughter, thank you for meeting this journey with such remarkable grace. There were times when I could not be fully present because of the work required to complete this dissertation, and you handled those moments with understanding, kindness, and grace. I am endlessly proud of you and deeply grateful for the way you walked beside me through all of this.

And lastly, I could never have gotten here without my Jesus. I am incredibly grateful for the numerous ‘lightbulb’ moments, the absolute love that stayed me, and the graces that were multiplied upon me. For the strength I cannot explain, the open doors I did not deserve, and the support system God intentionally surrounded me with, I am grateful.

To everyone mentioned here, this achievement is as much yours as it is mine.

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List of Abbreviations

Anti-TNF	Anti-tumor necrosis factor
BCW	Behaviour Change Wheel
CAD	Canadian Dollar
CCC	Crohn's and Colitis Canada
CD	Crohn's Disease
CI	Confidence interval
CIHR	Canadian Institutes of Health Research
COM-B	Capability, Opportunity, Motivation – Behaviour
CRP	C-reactive protein
DT	Design Thinking
FITT	Frequency, intensity, time and type
GI	Gastrointestinal
HBI	Harvey Bradshaw Index
HRmax	Maximum heart rate
HRQoL	Health-related quality of life
IBD	Inflammatory Bowel Disease
ICF	International Classification of Functioning, Disability and Health
IL-6	Interleukin-6
IQR	Interquartile range
JCAG	Journal of the Canadian Association of Gastroenterology
KT	Knowledge Translation
KTA	Knowledge to Action
MD	Mean difference
MET	Metabolic equivalent
MVPA	Moderate to vigorous physical activity
PA	Physical activity
PMS	Partial Mayo Score
QoL	Quality of life
RCT	Randomized controlled trial
RoB	Risk of Bias
SD	Standard deviation
SMD	Standardized mean difference
SR	Systematic review
UK	United Kingdom
US	United States
V02max	Maximum volume of oxygen
WHO	World Health Organization

Chapter 1 – Review of Literature

Introduction

Inflammatory bowel disease (IBD) is a chronic inflammatory disorder of the gastrointestinal (GI) tract, consisting of two major forms: Crohn's disease (CD) and ulcerative colitis (UC) ^{1,2}.

Patients with CD have segmental and transmural (entire wall) involvement of ileum, colon and/or proximal GI tract ³, whereas lesions in UC are typically diffuse and superficial, involving the mucosa of the colon only ⁴. A dysregulation in the body's immune system which leaves the body at risk for chronic uncontrolled inflammation in the gut plays a role in both CD and UC ⁵. Both are characterized by an unpredictable cyclic nature, alternating between quiescent (inactive) and active states of inflammation ⁶⁻⁸. Active disease state (ongoing inflammation) can require hospitalizations, surgeries, and use of expensive therapies ⁶⁻⁸. IBD is therefore associated with substantial long-term morbidity ^{8,9}.

The diagnosis of IBD can occur at any age including infancy, however, the commonest age groups of diagnosis are adolescence and 20 – 30 years ^{9,10}. There have been remarkable recent advances in understanding IBD, however, the etiology is still not fully known and IBD remains incurable ^{8,9}. Importantly, the prevalence of IBD is increasing world-wide ^{4,11}. IBD is expected to affect 1.1% of the Canadian population by 2035 ¹². Canada has one of the highest incidence rates of IBD in the world, with Newfoundland and Nova Scotia reporting the highest incidences in Canada ^{9,13}. As prevalence of IBD in Canada continues to rise, healthcare systems are challenged with providing safe, high-quality and cost-efficient care to individuals with IBD ^{9,14}.

When individuals experience the active disease state of IBD, medical and surgical therapies are required to relieve symptoms and achieve mucosal healing ^{3,5,11}. In addition, to

maintain symptom remission or quiescent state of IBD, individuals frequently need to remain on medical therapies ³. Several studies have reported that even when in quiescent disease state, some individuals continue to have persistent symptoms such as fatigue, urgency, abdominal pain and joint pain; as well as psychological symptoms such as stress, anxiety and depression ^{6, 15-17}. These persistent symptoms significantly reduce the health-related quality of life (HRQoL) of those with quiescent IBD ¹⁷⁻¹⁹. Kamp and Stommel ²⁰ highlight this in their case-control study that revealed that some individuals with quiescent IBD experience low HRQoL when compared with age- and gender-matched individuals in the general population. In addition to reduction in HRQoL, presence of these persistent symptoms impacts negatively on the perception these individuals have about their chronic disease ¹⁷. Consequently, individuals with quiescent IBD continue to seek adjunct therapies to manage their disease and improve their HRQoL ^{1, 21, 22}. A developing IBD research focus is alleviating symptom burden in the quiescent disease phase ²³.

The use of complementary therapies to manage and alleviate symptom burden is increasing among all chronic health conditions ²⁴. Physical activity (PA) has been identified as one of the complimentary therapies that may be beneficial in the management of IBD ^{1, 21}. Several small heterogeneous studies ^{1, 2, 6, 7, 25} suggest that PA and exercise can relieve symptoms and improve HRQoL in individuals with IBD. PA may exert this effect by enhanced immunological response, improved psychological health, and by restoring lost muscle mass and strength ⁶. Additionally, the World Health Organization (WHO) recommends PA for adults with chronic conditions ²⁶ as it can improve quality of life (QoL), reduce rate of disease progression and contribute to healthy aging ^{26, 27}. However, the majority of individuals with IBD do not participate in recommended levels of PA ^{2, 28}.

Participation in, and adherence to, a PA regimen may be challenging for individuals with IBD due to residual symptoms such as fatigue, abdominal pain, joint pain, fecal urgency, incontinence, anxiety and depression ^{2, 22}. Furthermore, PA guidelines specific to individuals with IBD are lacking ^{7, 28}. Also, the few existing trials on PA in IBD are heterogenous in their methodologies ^{16, 22}. Considering the available evidence, motivating individuals with quiescent IBD to engage in PA is challenging for healthcare providers especially as this may require a complex behaviour change and significant commitment ²⁹. Thus, there is a need for a PA program designed specifically for individuals with quiescent IBD, which incorporates strategies to improve their participation and adherence, so that they can take advantage of the potential benefits of PA to improve QoL and possibly alleviate persistent symptoms in quiescent disease.

Inflammatory Bowel Disease

IBD is a chronic condition that presents with intestinal and extraintestinal manifestations ^{1, 2}. A 2012 study ³⁰ reported a 0.67% prevalence of IBD in Canada, with 129,000 Canadians living with CD and 104,000 with UC (total of approximately 233,000). By 2018, the prevalence had risen to 0.7% with approximately 270,000 Canadians living with IBD ⁹. As of 2023, the prevalence of IBD in Canada was 0.82% with 322,600 Canadians estimated to be living with IBD, indicating a rise of 0.58% in IBD per year ¹². In Manitoba, a 1999 study reported a prevalence of 198.5/100,000 for CD and 169.7/100,000 for UC ³¹. In a 2018 study, the incidence of IBD in Manitoba was reported to be 19.8/100,000; with an incidence of 8.9/100,000 for CD and 10.8/100,000 for UC ⁹. The prevalence of quiescent or mildly active IBD in Manitoba is unclear. As of 2023, the incidence of IBD in Canada was reported to be 30 per 100,000 person-years, indicating that more than 11,000 Canadians were diagnosed with IBD in 2023 ¹². These

numbers highlight that the Canadian healthcare system will need to be equipped to manage the rising burden of IBD.

Intestinal involvement of IBD can lead to abdominal pain, diarrhea, impaired nutrient absorption, and GI blood loss ^{4, 32}. In CD, the transmural intestinal inflammation (involvement of all layers of intestine) can lead to intestinal complications such as fistulas, strictures and abscesses; all which can require surgery ³. Some patients with extensive UC (pancolitis) may present with inflammation of the most distal part of ileum (backwash ileitis) ⁴. However, this inflammation in UC remains superficial involving only the inner most layer (mucosa) of intestine and does not include strictures or fistulas ⁴. Extraintestinal manifestations of IBD, occur due to involvement of bones, joints, skin and eyes, and can occur in 1 out of 4 individuals with IBD ³³. Extraintestinal manifestations include fatigue, arthritis, erythema nodosum, iritis, uveitis, low bone mineral density and loss of muscle mass ^{15, 25}. Some individuals may also present with constitutional signs and symptoms such as fever, weight loss and growth failure ^{3, 33}.

As there is no cure for IBD, medical therapy traditionally has been primarily aimed at resolution of symptoms during a flare, and maintenance of symptom resolution ^{1, 5}. Biological therapy, 5-aminosalicylates (5-ASAs), and corticosteroids (e.g., prednisone, budesonide) are used to induce remission during flares ^{3, 11}. When drug therapy fails, surgery is often required ⁵. Most patients who achieve remission continue to use medications for maintenance therapy ³. Medical management of IBD includes use of corticosteroids (e.g., prednisone), 5-ASAs (e.g., mesalamine), immunomodulators (e.g., thiopurines, methotrexate), and biological therapy including anti-tumor necrosis factor (anti-TNF) agents (e.g., infliximab, adalimumab, golimumab) ^{3, 5, 11}.

Symptom burden in IBD is greater during periods of active intestinal inflammation compared to periods of inactive disease state, that is in quiescence ^{4, 34}. Quiescence in IBD refers to periods when the disease is inactive, showing no or minimal clinical symptoms due to IBD and/or no evidence of inflammation on endoscopic or histologic assessment ³⁵. Clinical quiescence refers to absence of patient-report of symptoms attributed to inflammation, such as diarrhea, rectal bleeding, or urgency ³⁶. Endoscopic quiescence refers to absence of visible mucosal inflammation on endoscopy ³⁷. Histologic quiescence refers to absence of microscopic inflammation in biopsy samples ³⁸. However, symptoms may not correlate with the presence of active inflammation on endoscopy and/or histology in the GI tract, as some individuals with IBD continue to have symptoms even in the absence of intestinal inflammation ³.

Several studies have reported the prevalence of persistent physical symptoms such as fatigue, abdominal pain and joint pain; as well as psychological symptoms such as stress, anxiety and depression, among individuals with quiescent IBD ^{6, 15-17}. Pain, including abdominal pain is a common symptom in IBD ¹⁹. In their retrospective analysis of 122 patients with quiescent IBD, Coates et al. ¹⁷ reported that 74 had abdominal pain with one-third of the 74 patients reporting moderate to severe abdominal pain. This occurrence of moderate to severe abdominal pain led to increased corticosteroid use among participants. Further, they reported that those with abdominal pain in quiescent IBD were likely to have significant symptoms of anxiety and depression. A nationwide Swiss IBD cohort study of 1,263 individuals with IBD, followed up participants for a 5-year period after disease diagnosis. Among participants, 71% experienced pain at some point during the follow-up; with 52% of those experiencing chronic pain and 59.5% experiencing abdominal pain ¹⁹. Unfortunately, this pain was often untreated and significantly associated with low levels of HRQoL.

Peripheral joint pain and chronic back pain have been reported to occur in about 10% of people with IBD^{33, 39} and are associated with significantly lower levels of disease-specific QoL⁴⁰. In a 20-year longitudinal study involving adults with IBD, the prevalence of arthritis and spondyloarthritis were found to be 17.2% and 27.9% respectively, suggesting that one in six individuals with IBD and one in four experience IBD-related arthritis and spondyloarthritis respectively within 20 years of disease course⁴¹. Arthralgia (joint pain without inflammation) is more commonly experienced in IBD than arthritis (inflamed synovium of the joints)⁴². A United States National Health survey estimated the prevalence of joint pain in individuals with IBD and those without IBD. The prevalence of arthralgias was reported to be 30% among those with UC compared to 12% in the general population⁴³. A prospective longitudinal study³⁹ involving 155 individuals with IBD who experienced chronic pain found that 80 of the 155 participants had peripheral joint pain and 62 had back pain at baseline. At 1-year follow-up, the majority of participants reported that joint and back pain remained unchanged. Peripheral joint pain in IBD often involves smaller joints such as wrists or ankles, usually in a symmetrical manner⁴². Arthralgias may also be found (usually unilaterally) in larger joints such as the shoulder joint, albeit rarely⁴².

Fatigue can be understood as a persistent sense of tiredness, weakness, or lack of energy that results in difficulty or inability to initiate or sustain physical, cognitive, or emotional activities, and is often not relieved by rest^{44, 45}. Fatigue has also been identified as a persistent symptom in IBD^{16, 18, 32, 46}. A 20-year longitudinal study involving 440 individuals with IBD, reported significantly higher fatigue scores in this cohort than in the general population³⁴. While the prevalence of fatigue in active IBD is estimated to be as high as 86%, it persists even when IBD is no longer active or only mildly active⁴⁷. Fatigue in active IBD might be expected due to

symptoms of active IBD such as diarrhea, loss of appetite, and bloody stools, however, the etiology of fatigue in quiescent IBD remains to be fully elucidated. It has been hypothesized that fatigue may be due to elevated levels of circulating cytokines in the absence of obvious symptoms of inflammation, i.e., a subclinical pro-inflammatory state ⁴⁶. Prevalence of fatigue among individuals with quiescent and mildly active IBD ranges from 39% - 64% ^{16, 18, 34, 48}. Artom et al. ¹⁸ in their cross-sectional study involving 182 participants with IBD found that higher fatigue scores were associated with female sex, increasing levels of disease activity and performing less than 30 minutes of PA each week.

Chronic conditions such as IBD have been reported to trigger negative psychological responses including distress, anxiety and depression; and there may also be a bi-directionality between the presence of these mental health conditions and IBD ⁴⁹. A cross-sectional study ⁵⁰ involving 199 individuals with IBD assessed the effect of psychological manifestations on disease activity. Findings indicated that psychological manifestations such as anxiety and depression positively correlated with disease activity. They suggested further that when developing interventions to improve HRQoL, the effects of these symptoms should be considered. Similarly, a systematic review ⁵¹ investigating the relationship between social support and psychological symptoms among adults with IBD found that having social support, including emotional, informational and tangible support, can reduce the presence of these symptoms among adults with IBD.

Recent modeling studies on IBD management highlight the frustration expressed by individuals with IBD when treatment protocols do not optimally address persistent physical and psychological symptoms, and the value of incorporating the management of these symptoms in treatment plans ^{52, 53}. Even though IBD poses minimal risk of mortality ⁹, it places a heavy

burden on people as it reduces quality of life (QoL) and increases disability in those affected ⁴. IBD can negatively impact QoL because it often manifests with persistent symptoms, reduced ability to work and limited career choices, difficulty with physical intimacy and social stigma ⁵. Thus, the need for adjunct therapies to manage persistent symptoms and improve QoL cannot be over-emphasized.

Physical Activity and Exercise

Physical activity (PA) and exercise have been explored in the management of IBD. PA and exercise may exert modifying or controlling influences on environmental factors and improve impaired cardiovascular and muscular functions resulting from active disease ^{1, 11, 22}. The World Health Organization (WHO) defines PA as “any bodily movement produced by skeletal muscles that requires energy expenditure...including movement during leisure time, for transport to and from places or as part of a person’s work” ⁵⁴. Exercise, according to the WHO, is a “subcategory of physical activity that is planned, structured, repetitive, and purposeful in the sense that the improvement or maintenance of one or more components of physical fitness is the objective”. PA and exercise have been reported to be useful tools to prevent disease, and performance of PA at the doses recommended by the WHO results in improved QoL in the general population ⁵⁵.

PA can range in energy expenditure from very low levels of intensity (1 metabolic equivalent or MET) to very high levels of 9 to 20 METs ⁵⁶. Metabolic equivalent (MET) refers to oxygen consumption/energy expenditure at rest; a metabolic and physiologic value used to grade exercise intensity and capacity ⁵⁷. As delineated by the WHO ²⁶, light or mild intensity PA are activities that cause only a minimal increase in heart rate or breathing rate (i.e., less than 3 METs of energy expenditure), e.g., slow walking and light house chores. Moderate intensity PA require

between 3 to 6 times the energy required at rest (i.e., 3-6 METs) and high intensity PA include activities that require more than 6 times the energy required at rest (i.e., > 6 METs).

Another way to measure activity intensity is by using Borg's Rating of Perceived Exertion Scale, which is a subjective scale to rate level of effort ⁵⁸. Using the 0-10 scale, moderate intensity activities are those that require levels of effort rated 5 or 6. High or vigorous intensity PA are those activities that require levels of effort rated 7 or 8 ²⁶. Measurement of heart rate is also used to determine the intensity of PA as heart rate increases or decreases in proportion to the required effort ⁵⁹. Maximum heart rate (HRmax) is the maximum number of beats per minute that the heart can achieve under certain conditions ^{60, 61}. One way HRmax can be estimated for an individual is by subtracting their age from a value of 220 ⁵⁹⁻⁶¹. For example, using the formula proposed by Fox ⁶⁰, the maximum heart rate for a 50-year-old is estimated to be $220 - 50$, which is 170 beats/minute. Based on this, mild, moderate and high intensity physical activities are defined as those that increase the heart rate to 57-63%, 64-76% and 77-95% of the individual's predicted HRmax, respectively ⁶².

Intensity of PA is inversely proportional to duration of PA, and high intensities of PA are often difficult to sustain over prolonged periods of time ⁵⁹. There are three main categories of exercise that challenge the body in different ways – aerobic, resistance and flexibility exercises. Aerobic exercises are those activities that engage the body's large muscles and the cardiopulmonary systems in repetitive movements over a sustained period (e.g., running, cycling); they are also called cardiovascular endurance exercises ²⁶. Resistance exercises, on the other hand, are those activities that specifically target increased skeletal muscle strength, endurance, power and mass ²⁶. Flexibility exercises are those activities that move the muscles

and joints through a full range of motion to encourage tissue elongation, e.g., static and dynamic stretching performed during warm up ⁶³.

Aerobic exercises confer benefits in apparently healthy individuals which include lowering body mass index (BMI), improving cardiovascular fitness and muscular endurance, as well as modulating hormones and neurotransmitters ⁶⁴⁻⁶⁷. In several chronic conditions, aerobic exercises can improve overall vascular health, cognitive functions, memory, glucose tolerance, cardiorespiratory fitness, and reduce HR recovery time ⁶⁸⁻⁷⁰. Several trials highlight how aerobic exercise can be beneficial in diverse chronic conditions. A systematic review ⁷¹ investigated the efficacy of aerobic exercise in relieving joint pain among individuals with knee osteoarthritis. The authors reported a significant reduction in joint pain with aerobic exercises. A 2015 meta-analysis ⁷² reported that aerobic exercise is effective in reducing fatigue in individuals with rheumatoid arthritis. Similarly, a randomized controlled trial (RCT) ⁷³ involving 24 participants was conducted to assess the effect of aerobic exercise on fatigue severity in individuals with pulmonary hypertension. Study findings showed that those in the intervention group reported a statistically significant decrease in fatigue severity and engaged in higher levels of PA compared to those in the control group.

Aerobic exercise was also found to be an effective non-pharmacological method of managing moderate to severe anxiety disorders ⁷⁴. This is in agreement with the results of several systematic reviews and RCTs investigating the effect of aerobic exercises on stress, anxiety and depression ⁷⁵⁻⁷⁷. In a systematic review ⁷⁴ that investigated the effect of aerobic exercise on anxiety, the analysed sample involved 66% women, and 80% of the total sample rated severity of anxiety as moderate to severe. Results indicated that aerobic exercise is effective in minimising symptoms of anxiety, even though there is still a lack of consensus on the optimal intensity of

exercise. A recent RCT ⁷⁸ to assess the effect of aerobic exercise on depression, randomised 66 young adults to 8 weeks of moderate intensity aerobic exercises or light stretching. Study findings showed that aerobic exercises resulted in greater symptom reduction compared to stretching. Aerobic exercises have been found to trigger positive mood ⁶⁴, which may be responsible for the effects of aerobic exercises on psychological disorders.

Resistance exercise is defined as ‘a physical conditioning program that enhances fitness, health, and sports performance, using a variety of training modalities such as free weights, weight machines, medicine balls, elastic bands, and different movement velocities’ ⁷⁹. Resistance training offers the most effective method for developing musculoskeletal strength, hypertrophy, and motor performance ^{80, 81}. During resistance training, exercise is often performed against a load (mechanical loading) for a short duration which can result in increases in muscle size (hypertrophy), neural adaptations and increased strength ⁸². During mechanical loading, tendons pull on the bone at the insertion sites; the inherent need to maintain skeletal homeostasis is stimulated, and osteocytes responds to loading by signaling osteoclasts and osteoblasts to elicit bone formation, thereby strengthening the bone ⁷⁹. Thus, resistance training results in strengthening of bones, as well as muscles.

Hypertrophy, bone strengthening, as well as neuromuscular and connective tissue adaptations, all lead to the increase in muscular endurance and strength observed in resistance training ⁸². These effects of resistance training combat physiological susceptibility (deconditioning effects that occur in neuromuscular and skeletal systems such as bone loss and muscle atrophy) and influence functioning, mobility and psychological well-being ⁸³ in both healthy individuals and those with chronic conditions. Additionally, resistance training improves bone mineral density as demonstrated in several trials ⁸⁴⁻⁸⁶. A systematic review ⁷¹ revealed that

non-weight bearing resistance training was efficacious in relieving joint pain in those with knee osteoarthritis. The result of an RCT that investigated the effect of resistance training in 126 obese older adults with compromised muscle function, found an improvement in muscle strength and physical functioning ⁸⁷. Furthermore, a 2018 systematic review ⁸⁸ reported that resistance training improved quantity and quality of sleep, both which are crucial for overall good health. These benefits may relieve stress and anxiety and improve overall QoL. Resistance exercises may also improve movement control, cognitive abilities and self esteem ⁸⁹, which may encourage participation and adherence to PA. The result of increased strength, muscle mass and muscle power brought on by resistance training is a general increase in functional capacity ⁹⁰.

Flexibility exercises are those activities that move the muscles and joints through a full range of motion to encourage tissue elongation, e.g., static and dynamic stretching performed during warm up ⁶³. Flexibility exercises can reduce muscle shortening, improve range of motion at joints and prevent the cascade of postural and balance problems that may arise from muscle shortening and reduced range of motion ⁹¹. This is in agreement with the findings of a systematic review that assessed the effect of flexibility training on functional outcomes. The findings of the review showed that flexibility-specific interventions improved range of motion ⁹² which can improve safe performance of other forms of PA. Flexibility, especially dynamic flexibility, has also been reported to enhance production of bursts of power and improve sports-specific performance ⁹³. Additionally, flexibility exercises may reduce insomnia, pain intensity, fatigue and anxiety in among those with chronic health conditions ^{94, 95}.

Benefits of physical activity in healthy populations

It is widely known that PA is beneficial in healthy populations. PA confers significant health benefits on the heart, body and the mind, reduces the symptoms of anxiety and depression and contributes to the prevention and management of noncommunicable diseases such as cancer and diabetes ²⁷. PA reduces overall systemic inflammation; improves cognitive status, executive functions, heart muscle functioning; and is advantageous for older adults who are at increased risk for disability and subsequent loss of independence ⁹⁶⁻¹⁰⁰. Previous research also indicates that PA improves overall cognitive status and improves physical function. A 2019 RCT was performed to determine the efficacy of PA to improve cognitive function in healthy adults (age 20 - 67 years). The study reported a significant increase in executive functions and cortical thickness with aerobic exercises ¹⁰¹. Similarly, an RCT involving healthy young males to determine the effects of a single bout of aerobic exercise on learning found that aerobic exercises of at least moderate intensity might promote brain plasticity thereby improving learning ¹⁰². Furthermore, the result of a systematic review ¹⁰³ demonstrates that performance of high levels of PA is positively associated with healthy ageing. Additionally, risks of insulin resistance, type 2 diabetes and metabolic syndrome reduce with regular PA ¹⁰⁴.

PA contributes to reducing overall systemic inflammation ^{105, 106}. C-reactive protein (CRP), a protein which increases when there is inflammation in the body, and IL-6, a protein that serves as both a pro-inflammatory cytokine and anti-inflammatory myokine, are frequently measured to assess inflammatory processes within the body ¹⁰⁷. Donges et al. ¹⁰⁸ investigated the effect of a 10-week resistance and aerobic training program on CRP and IL-6 concentrations in a sedentary otherwise healthy adult population. They reported a reduction in CRP concentration in the resistance training group, and a trend for reduction in CRP concentrations in the aerobic

group, with no reduction in IL-6 for both exercise groups. Another study ¹⁰⁹ reported a significant reduction in CRP following a 2-month aerobic training program in apparently healthy women. It has been suggested that chronic muscle contractions achieved with sustained PA participation decrease IL-6 concentrations ¹⁰⁵. However, a single bout of strenuous exercise acutely increases IL-6 concentrations and other acute phase reactants ^{110, 111}.

Benefits of physical activity in chronic conditions

In addition to the benefits of PA in apparently healthy individuals, there is also mounting evidence that PA, including aerobic exercise, resistance training, yoga, etc., is beneficial for individuals with diverse chronic conditions. According to the WHO, PA improves the QoL of those with chronic conditions and contributes to healthy aging ²⁷. The RCT of Nicklas et al. ¹⁰⁵ investigated the effects of 12-month moderate intensity PA intervention (combined aerobic, resistance and flexibility exercises) on systemic inflammatory biomarkers, CRP and IL-6, in older adults. The result of their RCT revealed a 32% and 16% reduction in CRP and IL-6 respectively in this population. In those with rheumatic diseases, yoga was found to improve overall QoL according to a systematic review involving 23 studies ¹¹². Similarly, PA was found to improve health-related indicators in those with type II diabetes mellitus, as reported in the findings of an RCT assessing the effect of two intensities of aerobic exercises (moderate and high intensities) ¹¹³. Furthermore, research has shown that aerobic exercise is an effective non-pharmacological measure in the management of hypertension as it prevents or reduces high blood pressure ⁵⁹. An RCT ¹¹⁴ that evaluated the effects of a 6-month aerobic and resistance training program in individuals with pulmonary hypertension revealed an improvement in functional status, psychological aspects and health-related quality of life (HRQoL). Engaging in

PA programs encourages weight loss, and both improves function and reduces pain in those with hip and knee osteoarthritis ¹¹⁵.

In addition to the health benefits of PA in those with chronic conditions, PA also leads to lower healthcare costs ¹¹⁶⁻¹¹⁸. For example, PA prevents and/or slows the progression of chronic health conditions such as diabetes and hypertension, leading to reduced need for medical interventions ^{116, 119}.

Benefits of physical activity in the IBD population

PA reduces inflammatory responses generally ¹²⁰, and in the IBD population, PA may also positively affect gut microbiota ⁵⁵ thereby modulating systemic/bowel inflammation. The gut microbiota is a collection of bacteria, archaea and eukarya, populating the GI tract, specific compositions of which seem to strengthen the integrity of the gut, protecting as well as providing immune regulation for the host ¹²¹. An abnormality in this microbial population is believed to result in dysregulation which causes inflammation and mucosal lesions seen in IBD ¹²². Fortuitously, the gut microbiota composition is susceptible to shaping by both environmental factors and host factors ¹²¹. Additionally, the gut microbiome, similar to skeletal muscle, is plastic and can respond to environmental factors like PA/exercise by altering its composition ¹²³. Increasing evidence suggests that regular aerobic exercise is beneficial to the gut microbiota, as it increases microbial diversity (which is beneficial for a healthier state) and increases the health-beneficial gut bacteria populations ^{55, 122, 124}.

The impact of exercise on gut has not been well elucidated, however, it is plausible that exercise represents a hormetic stressor to the gut, triggering an adaptive response ^{55, 124}. This stimulates beneficial adaptations and improve long-term resilience of the gut barrier, reduce

transit time in the large intestine, accelerate movement of gas through the GI tract, increase mechanical forces in the abdomen which may potentially influence gut motility, and promote maintenance of an anti-inflammatory state ^{55, 124}. When metabolic needs increase during increased intensities of PA, the body meets the increased demand by increasing and enhancing the efficiency of blood circulation ⁵⁹. This is achieved by 1) increasing cardiac output (increased heart rate and increased stroke volume), and 2) redistributing cardiac output away from visceral organs to active skeletal muscles with the skeletal muscles receiving up to 85% of total cardiac output ⁵⁹. This reduction in blood flow to the gut may present a hormetic stressor that stimulates beneficial adaptations. In addition, during increased levels of PA, muscle fibres release myokines and IL-6 (a cytokine or anti-inflammatory myokine) both of which have anti-inflammatory effects that can act on the gut, thereby improving immune function ^{2, 55, 125}.

Participating in PA may confer protective factors in the IBD population. The meta-analysis by Wang et al. ¹²⁰ involving individuals with IBD, and control participants without IBD, reported that high PA participation rates are associated with about 37% reduction in risk for developing CD. Similarly, there is a positive effect of daily PA on the maintenance of quiescence in IBD ². Additionally, engaging in high levels of PA, specifically greater than 150 min/week of moderate to vigorous PA is associated with improved HRQoL in people with IBD ¹²⁶. In the cross-sectional study of Chan et al. ⁷ involving adults with IBD, 72% of respondents reported that PA made them feel better, improved their general well-being and increased their confidence. Respondents also identified additional benefits including increased energy levels, reduced IBD symptoms, enhanced feelings of fitness and health, and improved sleep.

PA improves mood, physical fitness, and contributes to increases in bone mineral density, all of which promote improved QoL in IBD ². The changes in mood following aerobic exercises

have been attributed to increases in endogenous opioid release ^{64, 127} which play a key role in emotional processing ¹²⁷. The potential of aerobic exercises to trigger positive mood ⁶⁴ may be beneficial in managing anxiety and depression in those with these persistent symptoms. Additionally, the benefits conferred by resistance training to improve bone mineral density, muscle power and overall functional capacity ⁸⁴⁻⁸⁶ may combat low bone mineral density, relieve symptoms such as peripheral joint pain, and fatigue, and improve QoL in individuals with quiescent IBD. Thus, being able to participate in regular PA may confer benefits that reduce some persistent symptoms and improve QoL in individuals with quiescent IBD. However, most studies investigating PA in individuals with quiescent IBD have methodological limitations which include small sample sizes, unstructured PA interventions, subjective assessment of PA, and heterogeneity in available trials ^{126, 128-131}. These limitations reduce clarity on the efficacy of PA to improve QoL and reduce symptoms in quiescent IBD.

Barriers to Physical Activity Participation in the IBD Population

Globally, underprivileged groups, and people with disabilities and chronic diseases are among those who have fewer opportunities to access PA programs ^{132, 133}. The target of the WHO Sustainable Development Goals 2030 policy actions on PA is a 15% relative reduction in global prevalence of physical inactivity by 2030 ¹³². Despite the global efforts towards increasing PA participation, a large proportion of the population does not meet recommended guidelines ¹³⁴. In the USA, the prevalence of sufficient volume of leisure-time PA (at least 150 minutes of moderate intensity PA per week) evaluated using subjective measures was reported to be about 50%; and this is lower in women, inversely related to age, and lower for people with chronic diseases by 26% - 48% ¹³⁵.

An objective assessment of PA participation among Canadian adults 18 – 79 years of age, found an adherence rate of 39% (to the WHO PA guidelines) for moderate to vigorous intensity PA ¹³⁶. Similar findings with accelerometry measurements were obtained in a UK Biobank prospective cohort study involving 96,706 individuals ¹³⁷. The findings revealed that those with chronic conditions performed 61 fewer minutes of moderate intensity PA per week compared to those without chronic conditions. Of note, subjective assessments of PA typically overestimate PA levels compared to objective assessments ^{138, 139}. As with most individuals with chronic conditions, there is reduced PA participation among those with IBD ². The complications resulting from intestinal inflammation causing inhibition of intestinal function and sometimes, the need for surgery, contribute to reduced PA participation among individuals with IBD ³. Unfortunately, there are no defined activity guidelines for individuals (male, female, young or old) with IBD ².

Even though previous studies suggest PA and exercise can relieve symptoms and improve HRQoL ^{1, 2, 6, 7, 25}, the majority of individuals with IBD do not engage in the advised amounts of PA ². In the cross-sectional study of Chae and colleagues ²⁸ involving 158 adults with IBD (mean age of 46 +/- 17.6 years) participants self-reported they engaged in PA/exercise for an average of 103min/week, which is less than the 150 min/week recommended by WHO ²⁶. A UK survey study to assess level of PA following stoma surgery in 2,631 individuals revealed that 69% of individuals with stoma were not participating in recommended levels of PA with 18% reporting not being physically active at all ¹⁴⁰. Reasons for not participating in PA included fear of developing a hernia and worries about the stoma bag coming loose or leaking. In another cross-sectional study ¹²⁵, approximately 70% of participants reported that their IBD diagnosis affected their level of participation even though 87% of participants considered PA important in

their daily lives. This study also revealed that sports participation reduced upon receiving an IBD diagnosis irrespective of the prior level of sporting activity (amateur, semi-professional and professional levels).

Chae and colleagues²⁸ have suggested that when planning a PA program, identifying, and mitigating the barriers to PA are important to improve participation. The unpredictable cyclic nature of IBD may be an implicating factor in patients' abilities to participate in PA¹²⁵. Additionally, individuals with IBD may not find PA enjoyable²⁸. The majority of IBD patients believe they are able to participate in PA and exercise, but the lack of recommendations and clear guidelines have not facilitated participation²⁸. Russell et al.¹⁴⁰ revealed that about 68% of individuals with stoma reported not receiving any information about PA following stoma surgery, and 82% did not receive any information about core or abdominal exercises, even though they have been recommended to improve patient outcomes in this population¹⁴¹.

Participating in, and adhering to a PA program in the general population comes with barriers and challenges¹⁴². Several cross-sectional studies have shown that individuals with quiescent IBD may encounter additional barriers related to their disease course^{7, 28, 143, 144}. Hence it is imperative to understand the barriers to PA experienced by individuals with quiescent IBD, and their attitudes towards, and preferences for PA and exercise, so that members of this group can experience the benefits of PA²⁸. The social circumstances of individuals with IBD impact their outcomes and QoL^{133, 145, 146}, thus making social parameters worthy of attention when designing interventions. Furthermore, interventions aimed at increasing social interactions and those that reduce perceived stress may lead to improved HRQoL^{133, 147}.

Psychosocial factors influencing IBD and physical activity

Individuals with IBD may have very diverse social and clinical presentations that affect their disease course and disease outcomes quite differently. When planning interventions in this population, understanding the variability that exists is paramount. Those who have higher social participation have been reported to be more physically active ¹⁴⁸, hence factors that influence social participation may ultimately influence PA participation. Participation in general refers to the ability to be involved in life situations ¹⁴⁹. Social participation, according to the WHO's ICF (International Classification of Functioning, Disability and Health), refers to participation involving an individual's social life and social roles ¹⁴⁹. Social participation can be described as "a person's involvement in activities providing interactions with others in community life and in important shared spaces, evolving according to available time and resources, and based on the societal context and what individuals want and is meaningful to them" ¹⁵⁰. Social participation is a crucial health behaviour that promotes overall health and QoL, especially in those with chronic health conditions ¹⁵¹. However, disease state is inversely proportional to social participation; i.e., the more severe the disease the less the social participation ¹⁴⁵. There are several other factors that may influence social participation for individuals with IBD. It is important to understand these factors and potentially modulate them when developing interventions for members of these cohort so they can receive the benefits of PA.

The 2022 study of Su and colleagues (141) identified income, comorbidities, smoking, symptom burden of IBD and psychiatric comorbidities as predictors of social participation for individuals with IBD. Lower income and lower levels of education are prevalent social barriers associated with poor outcomes among individuals with IBD (129). Earning less than \$50,000 CAD annually was associated with lower participation in general, with females and those with

CD more implicated than males and those with UC (141). Those with IBD are more likely to be unemployed (after diagnosis) compared to the general population, thus putting them at risk for a lower socioeconomic status (148-150). Among those employed, employment may become precarious with the majority (91%) of those with IBD requiring at least one workplace accommodation to manage symptom burden, needing easy access to suitable washrooms and experiencing difficulties arranging those accommodations (151). Furthermore, one-third of those with IBD reported not feeling energetic enough to complete their tasks (151), and this may predispose them to requiring more workplace accommodations.

These social parameters may initiate or worsen psychological symptoms such as anxiety and depression, and stress. Importantly, psychological symptoms and high stress levels have been associated with nonadherence to treatment regimens (152) further complicating participation in general among individuals with IBD. Stress has been shown to negatively impact the course of IBD, exacerbating symptoms and increasing disease activity ¹⁵². High stress levels may trigger flare-ups and contribute to a diminished HRQoL in those living with IBD ¹⁵³. Furthermore, perceived stress can influence immune function and gut inflammation, further complicating disease management and daily functioning ^{152, 154}.

Smoking is an important environmental factor relevant in IBD disease course ¹⁵⁵. It has been established as a factor that increases the risk of CD but reduces that of UC ¹⁵⁵⁻¹⁵⁷. Additionally, smoking contributes to an unfavorable disease course especially in CD, and may contribute to anti-TNF non-response, making smoking status of clinical significance in the IBD population ^{156, 157}. Current smokers are also more likely to require surgeries for CD than those who never smoked ¹⁵⁵. Smoking impairs cardiac autonomic regulation and predisposes smokers to respiratory problems which may impact ability to perform beneficial intensities of PA ^{158, 159}.

Thus, smoking is an important factor to consider when designing PA interventions for individuals with IBD.

The most common age of IBD diagnosis is during the second and third decade of life ^{9, 10}, but diagnoses in those under 5 years of age have increased over the past two decades ¹⁰. And while the diagnosis of IBD in adults and older adults has been stable and is projected to remain stable over the next few years, the diagnosis of IBD in the pediatric population is projected to increase by 1.23% per year, up to 18.0/100,000 in 2035¹². Since IBD is a chronic condition without cure and with low mortality, those diagnosed early in life will carry the disease to older ages; having more unique co-morbid conditions in their senior years related to their disease course ¹⁶⁰. On the other hand, the presentation of IBD in older adults tends to be subtle ¹⁶⁰. Those diagnosed with UC at older ages are more likely to undergo surgery and those diagnosed with CD at older ages tend to exhibit more IBD-specific mortality ¹⁶¹. Older adults with CD are also more likely to have inflammation isolated to the large bowel and less likely to have perianal disease and other intestinal manifestations than their younger counterparts ¹⁶⁰.

Adolescents with IBD experience the disease differently from adults as they have other experiences unique to adolescence, such as delayed growth, and the psychosocial burden of the impact of IBD on their families ¹⁰. It appears there is no difference in the rates of CD-related surgeries between young and older adults, but there are higher rates of UC-related surgeries in older adults compared to young adults with UC ¹⁶¹. Polypharmacy is a challenge for older adults with IBD ¹⁶⁰, but is less of a problem for younger individuals with IBD. Epidemiological studies show that boys have a higher risk of developing CD than girls during early childhood, but girls have the higher risk starting in the second to third decade ^{162, 163}. Adult males, on the other hand, have a higher incidence of UC after the age of 45 years than adult females ¹⁶². Treatment

approaches for IBD are different based on age-group, especially because IBD treatments pose different risks depending on age; for example, chronic steroid use is associated with stunted growth in children ¹⁰.

In addition to the risks medications pose depending on age, there are also different risks depending on sex. Azathioprine is linked more with hepatosplenic T- cell lymphoma in young adult males than females, and since methotrexate is associated with birth defects, it presents a risk for women of child-bearing age ¹⁰. Sex-specific approaches to medication use in the IBD population have been recommended in a recent study that found that persistence of Adalimumab (a biologic) in the body is greater in males than in females and more female patients discontinue Adalimumab use due to side-effects than male patients ¹⁶⁴. Furthermore, female sex hormones, including oral contraceptives may contribute to exacerbation of IBD symptoms ¹⁶³. These factors further highlight the diverse social and clinical variability among individuals with IBD, all of which differently affect their disease course, outcomes and social participation. This emphasizes the importance of considering these factors when designing PA interventions for individuals with IBD.

Generally, the incidence of IBD is influenced by environmental factors, with IBD being positively correlated with white ethnicity, higher household income, employment status and tertiary education ¹⁶⁵. Individuals with IBD of lower socio-economic status, especially those with CD, demonstrate an increased use of services, have higher hospitalization rates and higher IBD-related mortality ¹⁶⁶. Medication adherence is crucial for positive outcomes in IBD management and socioeconomic status may account for the differences in medication adherence observed between socioeconomic groups ¹⁶⁶. Factors which affect socioeconomic status, such as age, income, and level of education, are always changing, further complicating their effects on IBD

outcomes ¹⁶⁶. Additionally, several studies show that the effect of environmental factors on the disease course of IBD are inconsistent, making it difficult to draw inferences following interventions ¹⁶⁶⁻¹⁶⁸. Nevertheless, identification of the attributes in IBD patients that make for decreased adherence and increased PA participation in general is necessary to consider to design successful interventions ¹⁶⁹.

Sex and gender differences

In IBD, sex differences related to epidemiology, disease course, medical and surgical management, adherence, and psychosocial functioning have been reported ¹⁷⁰⁻¹⁷². The composition of gut microbiota, which contributes to GI conditions, varies by age group as well as by sex, and microbiome is implicated in the circulation and excretion of sex hormones ^{172, 173}. To carefully explore the potential differences between men and women with respect to disease course and treatment effects, it is important to clarify the difference between sex and gender. ‘Sex’ generally refers to a set of biological attributes in humans primarily associated with physical and physiological features, leading to the categorization of sex as either male or female ^{174, 175}. ‘Gender’, on the other hand, refers to the socially constructed roles, behaviours, expressions and identities of girls, women, boys, men and gender-diverse people ^{174, 175}. According to the Canadian Institutes of Health Research (CIHR) ¹⁷⁵, biological attributes (sex) and sociocultural factors (gender), influence the risk of developing various diseases and how those affected respond to medical treatments; therefore, accounting for these attributes and factors in health research makes the resulting evidence more applicable to everyone. Understanding gender- and sex-specific differences related to treatment and adherence can foster a more personalized treatment approach and consequently, improve disease management ^{170, 171}.

With regards to the epidemiology of IBD, males and females have demonstrated distinction in both disease severity and clinical outcomes ¹⁶³. Issues specific to health of females, including pregnancy, childbirth, and menopause have a substantial impact on their clinical outcomes; for example, the immune system can be influenced by female sex hormones contributing to exacerbation of IBD symptoms ¹⁶³. Fluctuations in sex hormones are also associated with changes in disease activity, although available evidence has produced conflicting results ¹⁷². Several studies have identified worsening symptoms such as abdominal pain and fatigue over the course of the disease in females more than in males ^{17, 18, 34}. Females with IBD were also identified as requiring more workplace accommodations than their male counterparts ¹⁷⁶. A multicentre cohort study involving 2118 CD patients and 1269 UC patients found female CD patients were more likely to be current smokers, with male UC patients more likely to be previous smokers ¹⁷¹. However, a Dutch IBD Biobank study ¹⁷¹ concluded that even though sex differences are implicated in the age of onset and disease course in IBD, no major differences in the management of IBD between males and females were observed.

Even though there are many physiological similarities between males and females, important physiologic sex-based differences in response to dynamic exercise have been reported and these differences could impact exercise prescription and responses ^{174, 177}. Correlates of PA may vary across different sex subgroups, and these differences may account for differing levels of PA achievable and/or outcomes observed ¹⁷⁸. Males generally have a higher percentage of muscle mass in their upper body and this results in higher power production in males than females during upper body exercises ¹⁷⁹. On the average, males have longer stride lengths and lower stride frequency for a given walking speed than females ¹⁸⁰. Additionally, males are taller than females on the average, and thus have larger lungs; even though the elastic properties of the

lungs and thoracic cage are not sex-dependent ¹⁷⁷. Due to the differences in males and females, performance of some exercises is influenced ¹⁸⁰.

Exercise efficiency of males and females is similar ¹⁷⁹. However, physiologic measures of fitness and endurance such as V02 max, and hemoglobin are generally lower for females than males ¹⁸⁰⁻¹⁸². Sex differences in the pulmonary system's response to exercise are most observable during intense exercise ¹⁷⁷. For example, at maximal exercise, ventilation in females is lower due to the lower lung volume in females compared to males, leading to more increased work of breathing in females compared to males ^{177, 183}. These distinct sex-based differences impact performance of different types of PA among males and females and should be considered when designing PA programs for males and females with IBD.

Sex differences related to the body's responses to exercise have been widely studied, but the influence of gender has not received as much attention ¹⁷⁷. At younger ages, boys are generally encouraged to play games that are more physically intense, involving speed, strength, endurance and aggression ¹⁸⁴. Girls on the other hand are often pointed towards less competitive physical activities which involve role playing, solitary activities or games with a focus on turn-taking ¹⁸⁵. These socially constructed behaviours not only contribute to gender-based differences in PA participation, but may also impact gender-based differences in conceptualization of performance and participation of PA.

Several studies have demonstrated that level of performance and participation in sports activities are gender-mediated, with gender influencing parameters like physical self-concept, self-confidence and specific sports individuals choose to participate in ¹⁸⁶. A meta-analysis ¹⁸⁷ examining the magnitude of gender differences in self-confidence in PA found an effect size of

0.40 favouring men. A recent cross-sectional study¹⁸⁸ involving 90 elementary school students investigated gender differences in perceived and actual motor skill competence using the Tests of Gross Motor Development-2 and inertial sensor devices for objective measurements. The study reported that the majority of girls underestimated their object control competence while the majority of boys overestimated their level of competence. Study findings also revealed that overestimators participated in more sporting activities than underestimators.

Another cross-sectional study¹⁸⁹ involving teenage football players, 315 boys and 140 girls, found significantly higher scores in self-confidence, perceived self-competence and cognitive skills in boys than in girls. Essentially, there is a tendency for boys to participate more in PA than girls due to differing levels of self-concept and self-confidence. The intersections of these factors with the socioeconomic diversity in the IBD population may greatly influence the benefits gained from participation in PA and may also contribute to the complexity of behaviour change strategies required to encourage sustained participation in PA. An understanding of these differences is useful to examine variation in the effects of interventions while being conscious of the risk of over interpretation¹⁷⁸.

Behaviour Change

There is a clear imbalance between evidence of the benefits of regular PA and actual participation rates, and this has necessitated the development of behaviour change interventions to attempt to bolster participation²⁹. People make health-related behavioural decisions daily, such as brushing teeth after each meal or taking the stairs instead of the elevator; and while some of these decisions are easy, a significant number of behavioral decisions are unfamiliar and difficult to initiate and maintain, thus requiring additional supports¹⁹⁰. These additional supports may be provided in the form of behaviour change interventions. Behaviour change interventions

have been defined as “coordinated sets of activities designed to change specified behaviour patterns”¹⁹¹. These interventions indirectly influence the performance of a behaviour by focusing on the determinants of those behaviours, such as knowledge of consequences of the behaviour, awareness of the risks, and expected outcomes of the change.¹⁹⁰

Health care professionals are increasingly being encouraged to incorporate behaviour change interventions to promote public health in many different arenas which include PA and other health behaviours^{192, 193}. A recent systematic review¹⁹⁴ investigated PA behaviour change and maintenance in healthy inactive adults using the 93-item Behaviour Change Technique (BCT) taxonomy. The synthesis involved 26 RCTs of PA and sedentary behaviour interventions. Study outcomes showed that PA interventions that included behaviour change techniques, including biofeedback, graded tasks and prompts/cues, were effective at changing behaviour and maintaining the behaviour change for at least 6 months. Another systematic review explored behavioural interventions in colorectal cancer survivors aimed at improving vital health behaviours. Sixteen studies were identified that demonstrated a pattern of successful PA and dietary change as a result of behaviour change interventions of varying intensities and modalities¹⁹⁵. Similarly, a 2022 systematic review assessed the effectiveness of behaviour change interventions in the prevention of dental caries. Of the 36 included studies, 28 showed that behaviour change interventions had a significant effect on clinical and/or behavioural outcomes, with a statistically significant result for caries prevention at both surface and tooth level¹⁹⁶. The inclusion of behaviour change components in nutrition interventions was found to significantly improve maternal and child nutrition in sub-Saharan Africa according to a 2021 systematic review¹⁹⁷. This study also found that interventions that included two or more behaviour change components, such as persuasion, providing incentives and environmental restructuring, had more

positive outcomes. Thus, the benefits of including behaviour change techniques in interventions to promote public health, including promoting PA participation, cannot be over-emphasized.

Factors influencing physical activity behaviour change

Motivating individuals to initiate and maintain regular participation in PA has been challenging for healthcare professionals^{29, 192, 198}. This may be because participation in PA is different from other behaviours in that it is an adoption behaviour, which requires a significant time commitment, and not a temporary or one-time decision^{29, 190}. Thus, adoption of a lifestyle of consistent participation in PA represents a complex behaviour change. Simply focusing on the benefits of PA to improve health outcomes alone is not sufficient to encourage participation in PA¹⁹⁹. There are several clinical, psychosocial and demographic factors that are associated with participation and adherence to a PA/exercise program that have to be considered critically in PA behaviour change^{193, 200}. Some of these correlates of PA/exercise behaviour include age, sex, level of education, ethnicity, body weight, smoking status, climate, attitude, perceived control, self-efficacy, motivation, commitment, perceived barriers, spousal support, having home exercise equipment, distance from a fitness facility, financial and social resources, and exercise type and intensity^{29, 193, 200}.

Correlates of PA/exercise (such as age, sex, social resources, perceived control, motivation, and smoking status) may vary across different subgroups, and these differences may account for differing levels of PA achievable and/or PA outcomes¹⁷⁸. Some of these correlates have been identified as being related to attrition in PA programs¹⁹³. Understanding, incorporating and/or modifying correlates may facilitate the development of a PA program that minimises barriers to participation thereby encouraging and maintaining behaviour change²⁰⁰. For example, non-smokers will require fewer behavioural change strategies, and those who

reside close to a fitness centre may require less motivation to attend a fitness facility compared to those who reside farther from a fitness centre.

It is however important to note that not all correlates of exercise behaviour can be incorporated in a PA program. As asserted by Michie et al.¹⁹¹, even when multiple models and theories are used to guide intervention, they do not cover the full range of possible influences and often exclude important variables. It is thus essential to identify the key PA/exercise variables relevant to a subgroup in order to design effective behavioural change interventions in a PA program¹⁷⁸. Current research suggests that even when individuals engage with a PA program, fewer than 50% complete the program, giving rise to studies with insufficient power to appropriately determine efficacy of PA¹⁹³. Thus, adherence is an essential factor in PA programs, because if there is poor adherence, PA will not have the anticipated effect^{59, 200}. Unfortunately, PA participation and adherence are challenging even for apparently healthy individuals¹⁴².

Among individuals with quiescent IBD, PA participation and adherence may be more challenging due to persistent symptoms such as, fatigue, abdominal pain, joint pain and bowel urgency². Lamers and colleagues¹⁴³ reported individuals with IBD need to have access to bathrooms due to exercise-induced urgency, experience fatigue and pain, and some avoid PA altogether due to fear of aggravating joint pain or muscle pain. These factors affect patients' preferences for and adherence to PA. Preference, acceptability and enjoyment are important considerations when exploring and developing PA recommendations for clinical populations such as those with IBD^{28, 199, 201} to encourage behaviour change and long-term adherence. Correlates of PA/exercise behaviour may inform preference, acceptability, and enjoyment. Preference has been described as a "pattern of choosing" that occurs most frequently over time; it

is not a constant and may change with the introduction of a consequence or other independent variables ²⁰². Enjoyment especially facilitates motivation to change behaviour to adopt increased performance of PA ¹⁹⁹, and preference functions as a reinforcer in learning new behaviour ²⁰¹.

Strategies that facilitate behaviour change

Knowledge has been identified as an important strategy to change attitudes, norms and increase awareness ²⁰³. A meta-analysis ²⁰⁴ involving 44 studies revealed that higher levels of knowledge are associated with both intrinsic and extrinsic motivation. Knowledge and education that provides an understanding of why a behaviour has personal value, i.e., tailored knowledge, functions to increase awareness ²⁰⁵. This may not only increase motivation, but may influence preferences as well ²⁰⁶. Providing prompt and relevant information is probably the most widely utilized strategy to influence change in behaviour ²⁰³. Even though knowledge is an essential component of behaviour change, knowledge alone is not sufficient to change behaviour ²⁰⁵.

Enjoyment has been found to have a significant effect on PA adherence ²⁰⁷.

Unfortunately, PA is not particularly enjoyable for everyone ²⁰⁸. However, when motivation is high, enjoyment is also increased and this may facilitate behaviour change ²⁰⁷. It has been reported that increasing motivation is essential for most behaviour change interventions ^{209, 210}. Goal setting, presence of social support and positive affect have been identified as strategies to increase motivation ²¹¹. Of note, goal-setting as a strategy to increase motivation and change behaviour is most effective when the goals are realistic ²⁰³. This emphasizes the need to determine commitment and desire for PA (intention) as a baseline prior to commencement of a PA intervention, which then facilitates goal setting ²¹². Furthermore, social and financial supports contribute strongly to increase motivation which may facilitate adherence to PA ²¹³⁻²¹⁶.

Essentially, presence of knowledge, enjoyment and motivation may increase PA participation

and enhance adherence. Theories may help us understand the relationships between these factors and PA participation and adherence.

The Social Cognitive theory, a widely used causal model to understand PA behaviour change, suggests that even though individuals are both influenced by and react to their environment (physical and psychosocial), they are also capable of self-regulation, learning, and self-reflection; which enhances their self-efficacy, and this self-efficacy ultimately influences behaviour ²¹⁷. When people engage with tasks of increasing difficulty, they form beliefs about their capabilities (resulting from learning and self-reflection), and this efficacy belief may lead to behaviour change, depending on the presence or absence of relevant variables ²¹⁸ such as financial support, knowledge and access to equipment. Health promotion from the perspective of social cognitive theory has shifted from scaring individuals into healthy habits, to equipping them with self-regulatory capabilities to manage their own health habits and providing various social and physical supports to maintain their behaviour change ²¹⁹.

It is important to note that behaviour change is a process that often requires significant time commitment. The transtheoretical model of behaviour change conceptualises behaviour change as a process that evolves progressively over time through a series of five stages ²²⁰: 1) Precontemplation - no intention to change behaviour; 2) Contemplation - want to change behaviour but not committed; 3) Preparation - there is intention to change behaviour and taking small steps towards it; 4) Action - fully committed, and behaviour change is occurring; and 5) Maintenance - consistently engaging in actions that ensure behaviour stays changed ²²⁰. People can be in the precontemplation stage due to lack of knowledge and relevant information; or they may believe they do not have the capability to change ^{221, 222}. However, once individuals are able to cross over the precontemplation stage, goal setting, availability of social and financial

supports as well as positive affect may motivate them to start taking concrete steps toward changing behaviour ²¹¹.

Prochaska ²²¹ highlighted that the action stage is the most critical stage as this is the stage where individuals can either regress or progress and need the most support (motivation, resources, opportunities). In the later stages of behaviour change, reinforcement strategies (including rewards and enjoyment) are required to maintain performance of the desired behaviour ²²⁰. As Bandura ²¹⁹ suggested, individuals should be equipped with self-regulatory capabilities to maintain their changed behaviour. Ultimately, PA behaviour change includes not only the performance of the behaviour but the ability to consistently perform the behaviour in the face of diverse challenges and competing demands ²²³.

The benefits of behaviour change are maximised when the behaviour change is maintained, thus behaviour change without its maintenance is not sufficient ²²². In the case of PA behaviour change, participation is insufficient if adherence is not achieved. Several studies investigating PA participation in individuals with chronic conditions identify motivation as a key determinant of adherence ²²⁴. To delve deeper into this, motivation can be conceptualized as the energy that directs behaviour and this energy can come from diverse sources ²²⁵. The Self-Determination theory conceptually separates motivation into two types – intrinsic and extrinsic motivation ²²⁶. Intrinsic motivation is the drive to perform an activity simply based on the individual's preference for or enjoyment of the activity ^{227, 228}, e.g., crafting because of the enjoyment derived from the activity itself. Intrinsic motivation may be suppressed or enhanced by exposure to hostile or positive conditions respectively ^{229, 230}. Extrinsic motivation on the other hand is the performance of a behaviour solely because of a gain or avoidance of a negative consequence, which is separate from the activity itself ²³¹. It is not dependent on the individual or

the individual's preference for the activity but is prompted by an external source ²³², e.g., a student studying to get better grades or someone getting a job to receive the compensation. Both types of motivation are beneficial when developing an intervention, but they have to be incorporated carefully to achieve the desired behavioural change ²³³⁻²³⁵. The result of a systematic review ²³⁶ revealed there is a consistent positive association between motivation and PA, with intrinsic motivation being more prognostic of sustained adherence to exercise programs compared to external motivation.

Recent theories highlight that motivation involves interactions between individual attributes (goals, mastery, capability) and societal attributes (opportunities), and is not solely dependent on the individual ²²⁹. Three sources of motivation were identified by Touré-Tillery and Fishbach ²³⁷ – the desire to obtain external rewards (outcomes-focused, i.e., what they intend to gain – extrinsic motivation), to achieve internal rewards (intrinsic motivation) and the desire to maintain a positive self-concept (self-signaling). An individual's motivation to pursue a goal is thus dependent on personal preferences, available incentives, and the interactions between the individual and societal opportunities ²³². Motivation is further increased when ability to control outcomes is evident in the mind ²³⁰. This highlights the importance of graded goal setting. A cross-sectional study ²³³ found that negative motivation such as social pressure and internalized guilt, can reduce autonomy and competence (measures of intrinsic motivation). However, when motivation is internalized and has personal value, it supports satisfaction, intrinsic motivation and behavioural intention ²³³.

Theoretical underpinnings of physical activity behaviour change

Development of a behaviour change intervention is often informed by theories related to change in health behaviour ¹⁹⁰. Several studies have utilized behaviour change interventions based on

relevant theories to deliver PA programs, such as the social cognitive theory, theory of planned behaviour, the COM-B theory, self-determination theory, and the transtheoretical model ^{193, 234, 236, 238, 239}. Theories of behaviour change provide a framework upon which interventions are based and to understand the process of behaviour change ²⁴⁰. Use of theories results in development of interventions that have a higher likelihood of success and helps explain how each component of the intervention contributed to the overall success of the intervention ²³⁸. These theories provide clear statements of the processes hypothesized to regulate behaviour, and they are thus relevant to inform interventions involving behaviour change ^{241, 242}.

A theoretical understanding of the specific behaviour change is crucial in order to maximise the potential efficacy of an intervention ²⁴³. Behavioural theories are relevant, especially in this research program, because they can improve our understanding of the correlates of PA and their intersections ¹⁷⁸. They may also facilitate our understanding of how these intersections interact with the unique characteristics of individuals with quiescent IBD experiencing persistent symptoms. These theories present an accumulated knowledge of the mediators of the behaviour to be changed as well as the moderators of the change, including the a priori assumptions about what influences human behaviour ²⁴³. Of note, a mediator is a variable that explains how two variables are related while a moderator acts on the relationship between two variables potentially affecting the strength and direction of the relationship ²⁴⁴. Theories help us to identify and understand the mediators and moderators that are unique to a specific behaviour change.

It is becoming increasingly recognized that advancing theories of behavioural change is crucial in health research and practice ²⁴⁵. A 2016 meta-analysis ²⁴⁶ aimed at determining the effect of theory-based interventions focused on PA promotion among adults found that theory-

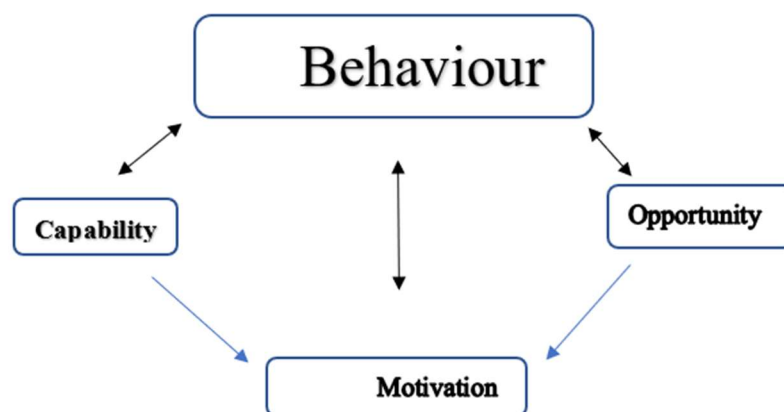
based interventions had a significant impact on changing the behaviour of participants towards PA. According to a 2021 systematic review ²⁴⁷, no one theory appears to be superior over others with respect to correlates of PA/exercise. With the goal of change in PA behaviour, the COM-B model may be a useful theory to understand the key mediators and moderators that change behaviour towards PA in the IBD population.

The COM-B model provides an overarching model that encapsulates factors that influence behaviour change ^{238, 248, 249}. Essentially, if a desired behaviour is lacking or an undesired behaviour is occurring, an assessment of the determinants of that behaviour is necessary to identify factors that need to change so that the desired behaviour can occur or for the undesired behaviour to cease ²³⁸. The COM-B model of behaviour change developed by Michie and colleagues ²⁵⁰ proposes that behaviour (B) will occur when three important conditions interact - capabilities (C), opportunities (O) and Motivation (M). Capabilities and opportunities influence motivation, and all three can potentially lead to the change in behaviour, which can in turn influence them. Capability can be defined as the extent of someone's ability or the power to do something ²⁵¹. Interventions often focus on capabilities, such as the availability of knowledge and skills, which can be enhanced through training and workshops ²⁵². The Opportunities condition refers to a favourable set of circumstances ²⁵³. Opportunity can be physical, i.e., made available by the environment, or social, referring to cultural interactions informing our perception of things ²⁵². Opportunity, unlike capability, is not produced by the individual but by the environment ²⁵².

Motivation on its own is a complex process, that is focused on achieving a goal and involves both the initiation and continuation of efforts aimed at achieving that goal ²²⁹. COM-B suggests that capability and opportunity influence motivation ²⁵⁰ by changing factors that initiate

or maintain motivation. Motivation results from changes in the ways we think and make decisions, thus the presence of opportunities and capability can spark or increase motivation ²⁵². Motivation can be used to avoid undesirable outcomes such as criticism and can also be used to pursue desirable outcomes such as a paycheck ²²⁵. Behaviour change is a combination of processes and stages, and not a one-time discrete event ^{220, 254}. Thus, behaviour change interventions that focus solely on capabilities assume motivation and opportunity are in place ²⁵² which can lead to ineffective interventions. To guide individuals through the stages of change needed to achieve the maintenance of the desired behaviour, individuals need to be equipped with the capabilities (e.g., graded tasks, knowledge, positive affect), opportunities (e.g., social support, environmental restructuring) and motivation (e.g., biofeedback, incentives, prompts/cues) to do so. Therefore, variables that promote these components need to be identified and incorporated in any behaviour change intervention.

Figure 1: COM-B Model ²⁵⁰



The COM-B model has been beneficial in understanding PA behaviour change in diverse populations. In a prospective study ²⁵⁵ involving 186 healthy adults exploring the predictive

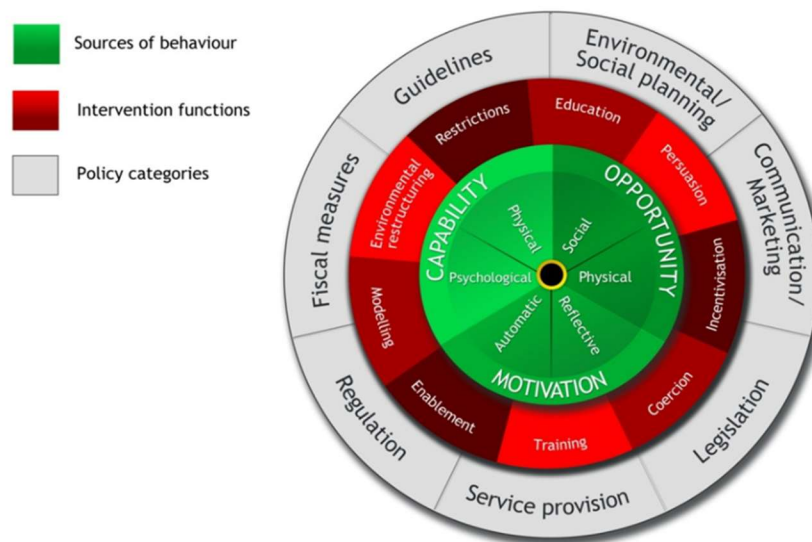
validity of the COM-B model for PA, capability (self-monitoring, habits, and action planning) and motivation (exercise self-identity, self-efficacy and intentions) were identified as key drivers of PA behaviour. Additionally, motivation was found to be a strong mediator for capability; whereas capability was found to be the most important driver of moderate to vigorous PA, followed by motivation and then opportunity. PA participation in the IBD population is low ^{143, 256}. A reluctance to participate in PA may be a reflection of feelings of incompetence or social exclusion, and is worth further investigation ²²⁵. Unfortunately, the literature around motivation in general (e.g., in terms of medication adherence, PA participation) in the IBD population is still sparse ²⁵⁷.

The COM-B model has been used across a variety of studies, including in IBD, to identify components that needed to be addressed to effect behaviour change. A cross-sectional study ²⁵⁸ to explore the factors influencing postnatal PA according to the COM-B model, identified the range of factors needed to be addressed for new mothers to be more physically active. The authors were able to identify the factors that are unique to this population separate from the ones that are individualised. Similarly, a qualitative study ²⁵⁹ aimed at exploring patient perspectives on psychological distress in the IBD population used the COM-B model. The authors identified factors such as system-level barriers, financial barriers, lack of psychological supports and preference for individualised, virtual-based supports, as key factors to be addressed in order to promote capability, opportunities and motivation. The authors added that these factors would be incorporated in the development of a patient-centred intervention in the management of psychological distress.

Following the analysis of findings derived using the COM-B, the next step is to link the components of the desired behaviour change to intervention elements. This is achieved using the

Behaviour Change Wheel (BCW), also developed by Michie and colleagues ²⁵⁰ following the synthesis of 19 behaviour change frameworks. The BCW is a non-linear model that provides a structured approach for matching the components (capability, opportunities and motivation) that need to be targeted for a behaviour change to occur, to components of intervention that can address them ²⁶⁰. The BCW is made up of three circles: 1) inner layer depicting the capability, opportunity and motivation components that need to be targeted; 2) the middle layer which provides a broad array of intervention functions to address the targets; 3) the outer layer which depicts policy aspects to ensure delivery of the intervention ^{250, 260}. The BCW provides a synthesis of the common features of behaviour change frameworks, linking them to a model of behaviour change that is broad enough to be applied across behaviours and settings ²⁵⁰. This positions the BCW uniquely to provide a model for the development of PA behaviour change interventions specific to individuals with quiescent IBD.

Figure 2: The Behaviour Change Wheel (used with permission) ²⁵⁰



Wearable devices

In recent times, wearable devices have gained popularity in motivating and engaging users in the delivery of health behavioural interventions ²⁶¹. Wearable devices can be worn on any part of the body, and can even be swallowed, to collect data ^{262, 263}. These devices collect information and provide feedback on a wide array of data such as steps taken, heart rate, movement quality, active vs. passive activities, calories burned, sleep quality, water consumption and even mood monitoring ^{261, 264}. Additionally, some wearable devices allow users to pre-select their goals ²⁶⁵, such as step counts per hour or per day, which may facilitate motivation. Depending on their design, monitors can consistently and continuously gather data, and they are swiftly becoming part of our day-to-day experiences and interactions ²⁶³. Wearable devices provide content that may enhance users' motivation, reshape their conceptualization of the body, and provide quantifiable ways of accounting for the body's interactions with the environment ²⁶³. However, as with most technologies, wearable devices come with disadvantages including cost of purchase, missed/lost data, and low durability ²⁶⁵.

With easy access to personalized health metrics, users are discovering that overall health is the sum of small choices made daily ²⁶⁴. Wearable devices, through the process of setting and achieving numerical goals, can assist users with forming habits via achievable daily choices ²⁶³. To facilitate formation of habits, wearable devices have the capability to provide users with hourly prompts to move and daily reminders to increase physical activities ²⁶⁴. An accelerometer is an example of such a wearable device used to monitor PA, which in addition to providing objective assessment of PA intensity and energy expenditure, also provides information about PA patterns which may be crucial for future implementation of effective PA programs ⁵⁹. Other types of wearable devices for PA include smart watches and fitness trackers.

Asimakopoulos and colleagues ²⁶¹ performed a 4-week assessment of two fitness trackers on self-efficacy and design implications in apparently healthy adults. They reported that fitness trackers were valuable for self-efficacy to increase PA participation. The built-in applications of such devices facilitate intention to change behaviour among users, such as by providing prompts, reminders and feedback, thereby supporting the users' overall goals. Zhou et al. ²⁶⁶ using a sample of 970 adults examined how technology affordances (the potentials within a technology) of wearable devices increase engagement. They found that technology affordances such as customization increased users' sense of autonomy, competence and relatedness which then led to increased engagement. A 2020 study ²⁶⁵ exploring the features of wearable devices that promote engagement identified motivational cues, challenges and general health information (such as heart rate levels, estimated energy expenditure) as the most useful features facilitating behavioural change. Additionally, recent studies suggest that the ability to share activity data with family and friends significantly influence exercise intentions ^{261, 263, 265, 267}. Evidently, arming patients with information about their health empowers them to make meaningful behavioural changes ²⁶⁴. Furthermore, by harnessing these attributes of personalization, goal-setting, and engagement offered by wearable devices, healthcare providers can potentially improve health outcomes for their patients ²⁶⁴.

With virtual delivery of healthcare increasing in popularity ²⁶⁸⁻²⁷⁰, providers and those receiving healthcare may use wearable devices to improve engagement and to facilitate collection of health metrics that would typically be collected in-person ^{271, 272}. Healthcare providers are relying more on patients with chronic health conditions to self-report their health information, making access to objective data essential in order to improve health outcomes ²⁶⁴. IBD is a chronic disease where the use and application of wearable technology may be able to

improve disease management, as well as contribute to evolving research needs ²⁷³. In this population, wearable devices can allow users and healthcare providers to access feedback on effects of interventions which can then be used to determine success of intervention or need for modification ²⁶². In a one-year prospective study, Sossenheimer and colleagues ²⁷⁴ used Fitbit smart watches and a smartphone app to determine correlations between level of PA and disease activity among individuals in all disease phases of IBD. They found that fewer daily steps were taken by participants in the week prior to measurements of high inflammatory markers, thus making it feasible to predict disease activity by level of physical activity. Importantly, several studies show that individuals with IBD find wearable devices acceptable ²⁷³.

Smartphone applications (which may improve interaction with collected data) used in tandem with wearable devices offer diverse technological possibilities in addition to or as part of techniques used in eHealth; including monitoring/sensoring, real-time support and may offer adapted behavioural change techniques ¹³⁴. Smartphone apps and smart watches can facilitate delivery of behavioural change techniques including goal setting, self-monitoring, and feedback on performance of PA ^{59, 261, 275}. Use of smart watches and smartphone applications are an important component of PA programming as they are valid and designed to deliver strategies for improved wellbeing ^{263, 265}. The fundamental goal of these devices is to provide real-time feedback to users so they can appreciate how their behaviours impact their overall health, providing additional motivation to be more proactive about managing their health ²⁶⁴.

Methodological Considerations for the Thesis

Feasibility

To ascertain whether the intervention is likely to yield the results anticipated and to justify requesting funding for such interventions, it is important to establish the effectiveness of not only

the intervention, but the processes involved in launching the intervention; and this is where feasibility studies can be important ²⁷⁶⁻²⁷⁸. Launching a novel intervention in an RCT has the potential to be expensive and resource-intensive ²⁷⁷. RCTs are one of the high-level research designs for evaluating efficacious interventions, and feasibility studies are crucial to the success of their implementation ²⁷⁹. Feasibility studies can provide data that confirms that the study design is achievable, and recruitment for a larger RCT is possible ^{276, 280}. Morgan and colleagues ²⁷⁷ performed a study to determine whether feasibility studies save funding costs in the long run, as there are additional costs related to executing a feasibility study as well as delay in launching the full trial. Their results indicated that feasibility studies have the potential to avoid waste and reduce the risk of funding resource-intensive full trials that may end up not being successful.

Lack of clarity on the definitions of identical terms like ‘pilot’ and ‘feasibility’ can be problematic, as it leads to a dearth of guidance on the processes involved in the conduct of the research study ²⁸¹. According to Eldridge and colleagues ²⁸¹, feasibility studies and pilot studies are not completely separate constructs. According to these authors, feasibility studies seek to determine whether a study can be done, if it is reasonable to proceed with executing it and if so, how to execute it. A pilot study on the other hand is a subset of the feasibility study category. A pilot study seeks to provide answers to the feasibility questions during the execution of a miniature version of a fully designed future study or part of the future study. Feasibility studies occur much earlier in the research process as they produce a set of findings that identify uncertainties that need to be addressed in the design of the future study (including the design of a pilot study) as well as whether an intervention is worth being recommended for efficacy testing ^{278, 280, 282, 283}. On the other hand, the goal in pilot studies is to assess that all components of the

study processes and the intervention (including recruitment, randomization, and follow-up) can work smoothly together ²⁸².

Eldridge and colleagues ²⁸¹ suggested that investigators should consider feasibility as an all-encompassing concept referring to all studies that are done in preparation for a main study. They clarified that under this term, three types of studies may be conducted; 1) Feasibility studies that are not pilot studies, referring to those studies where components of a future trial are assessed for viability, including intervention development but without evaluating the intervention itself; 2) non-randomised pilot studies, which are the studies where all or some of the components of the intervention to be evaluated, as well as other processes to be executed in a future trial are carried out but excluding the randomisation component; 3) randomised pilot studies, referring to studies where the future RCT or some of its components including randomisation and intervention are conducted on a smaller scale.

Even though relevant findings are revealed in feasibility studies, the sample sizes are typically too small to draw conclusions about the efficacy of the intervention ²⁷⁶. Generally, sample size calculations may not be required, however, the recommendation is that the sample should be representative of the study's target population ²⁸⁴. Thabane et al. ²⁸⁴ developed a typology outlining four key outcomes to be assessed in feasibility studies, which are 1) process, 2) resources, 3) management, and 4) the scientific basis of the future trial. Essentially, feasibility in trials will assess for resource issues and process outcomes ²⁸⁵, evaluate acceptability and tolerability of the intervention ^{276, 282}, ascertain whether the research design and research questions align ²⁷⁷, determine feasibility of recruiting an appropriate sample size from the population of interest ^{278, 283}, and ascertain when partnerships with end-users need to be established or increased ²⁷⁸. At the end of the feasibility study, indicators of feasibility are

evaluated as either ‘achieved’ (indicators are robust enough and do not require any adjustments or require only minimal adjustments) or ‘revise’ (indicators require some adjustments to improve feasibility of study) ^{284, 285}. Feasibility results may result in researchers making the difficult decision to not progress to full trial ^{280, 284}.

Knowledge translation and theoretical approach

There is increasing recognition of the knowledge to action gap in research ²⁸⁶⁻²⁸⁹. Several studies have shown that there is a gap between what is known about PA as a potential adjunct therapy in the management of IBD, and the level of PA participation among individuals with IBD ^{28, 140, 290}. This is an unfortunate outcome since research in this field has been ongoing for more than two decades ^{1, 291}. It is possible this is because there is minimal end-user involvement in the knowledge creation process. To minimize the knowledge to action gap associated with this research program, Knowledge Translation (KT) is an essential component. According to the Canadian Institutes of Health Research (CIHR), KT is “a dynamic and iterative process that includes synthesis, dissemination, exchange and ethically sound application of knowledge to improve the health of Canadians, provide more effective health services and products and strengthen the health care system” ²⁸⁸. To ensure knowledge derived from this research program aligns with this mandate, the knowledge generation and dissemination processes were driven by CIHR guidelines.

Straus et al. ²⁸⁹ identified four competencies required for KT science in research activities. These are 1) the identification of the KT model/research; 2) performance of quality knowledge synthesis to address KT questions and gaps in research; 3) the use of qualitative methods to assess factors impacting evidence uptake; 4) and the assessment of knowledge uptake. As an initial step, which is the identification of a KT model, this research program was

grounded in the Knowledge to Action (KTA) framework. This framework is relevant to advance KT activities in this study because it was developed following comprehensive review and it is the framework adopted by the CIHR for promoting KT processes ²⁸⁹. The KTA framework provides step-by-step guidance to achieve effective KT outcomes. A representation of how this research program was guided by the KTA framework is depicted in Figure 3 ²⁹².

The KTA framework is made up of two separate but interrelated components - the Knowledge Creation funnel in the centre, surrounded by the Action Cycle ²⁹². Both components are made up of phases that have the potential to influence each other. The funnel, as described by Graham and colleagues ²⁹², represents the major types of knowledge used in healthcare and this knowledge gets more distilled (and more valid) as it moves down the funnel. The Action Cycle is made of phases that involve activities needed to be carried out to move knowledge to application or implementation. These phases encompass identification of the problem that needs to be addressed, selecting the appropriate knowledge to address the problem, adapting the knowledge to suit the unique characteristics of the knowledge users, while assessing barriers and facilitators to using the knowledge. The Action Cycle also emphasizes the inclusion of relevant stakeholders throughout the research process to ensure that knowledge, knowledge use and knowledge uptake continue to be valid.

After highlighting the KT model that was used in this research program, we discuss knowledge synthesis. Within the KTA framework, this an important step to generate evidence-informed knowledge, identify gaps in research as well as the know-do gap. In compliance with this framework, a systematic review (knowledge synthesis) was carried out to determine the available evidence on the safety and efficacy of PA to reduce symptoms and improve HRQoL in

individuals with quiescent IBD. This synthesis also aimed to verify the level of PA participation and adherence by individuals with quiescent and mildly active IBD.

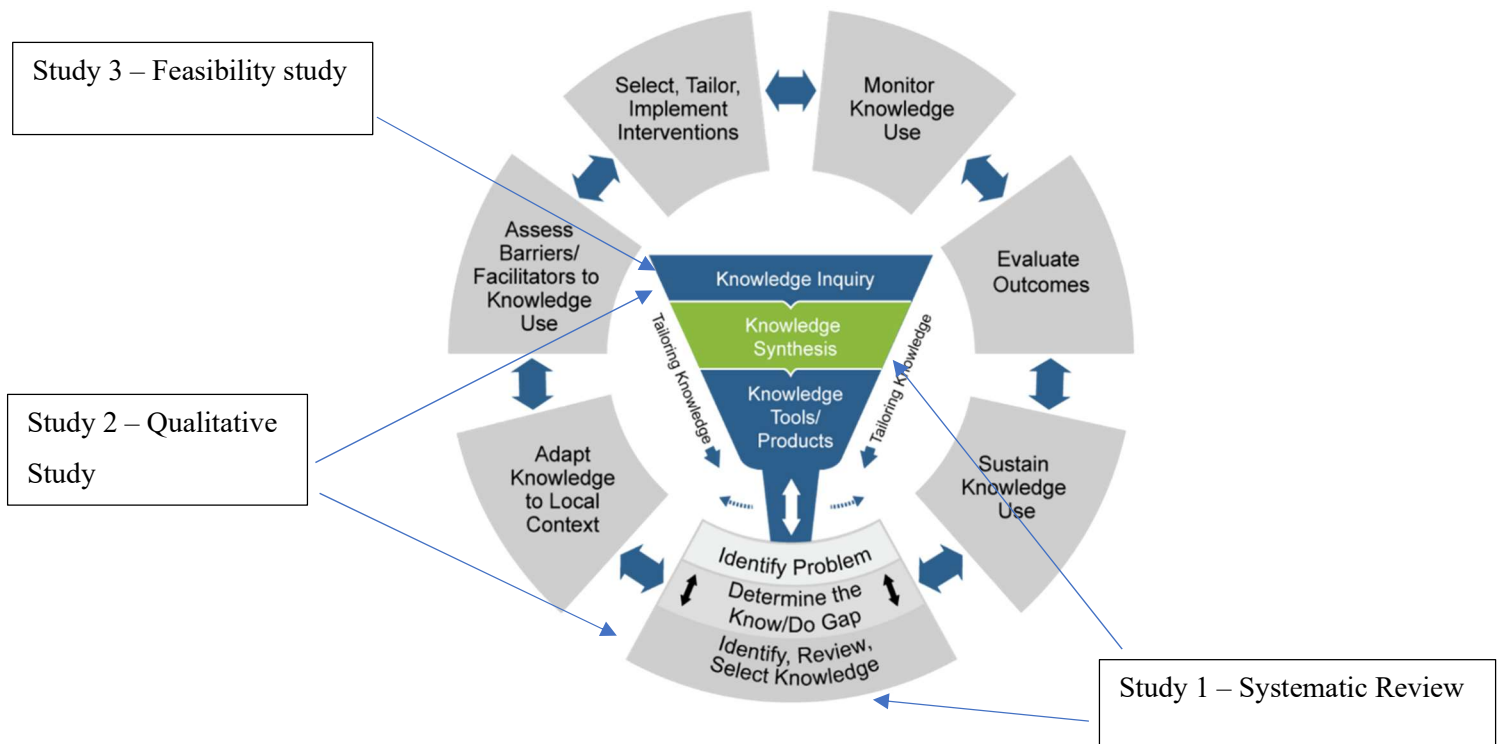
In keeping with the KTA framework, the next step in this research program after knowledge synthesis was informed by phases in the Knowledge Creation funnel and Action cycle. This step involved assessing barriers and facilitators to the use of the knowledge (generated from knowledge synthesis), exploring the factors responsible for the gaps in research, and generating more knowledge on the subject. This next step aimed to assess the factors or variables unique to individuals with quiescent or mildly active IBD that function as barriers and facilitators to PA participation using qualitative methods. Additionally, we explored strategies to tailor and individualise available evidence on PA in the IBD population.

Lastly, from the findings of the knowledge synthesis and qualitative study, a PA intervention that is unique to adults with quiescent and mildly active IBD was developed and its feasibility was assessed in a non-randomized pilot trial. Within the KTA framework, the goal of this step is to adapt the previously generated knowledge to the unique characteristics of individuals with quiescent IBD as well as perform knowledge inquiry. As has been previously mentioned, the phases within the KTA framework are dynamic and iterative, and the different phases will often inform each other.

Throughout this research program, individuals with IBD were involved as patient partners. Belton and colleagues²⁹³ highlight the risks of not involving patient partners in research; including 1) answering research questions that do not relate to pertinent aspects of the patient experience; 2) assessing outcomes of minimal importance to patients; and 3) minimal KT activities which limits real-world application of research findings. To mitigate such risks in this

research program, patient partners were continuously engaged throughout the research processes. In research, patient partners have been engaged to play various impactful, often overlapping roles, succinctly described by Crocker and colleagues ²⁹⁴ as “ ‘expert in lived experience’, ‘creative outsider’, ‘free challenger’, ‘the bridger’, ‘the motivator’ and the ‘passive presence’ “. In agreement, the results of a scoping review ²⁹⁵ highlighted that patient partners typically take on diverse roles within the research process, with partners receiving personal gains as well. The diversity in roles highlight the importance of establishing the exact role of patient partners in each research study from the outset.

Figure 3: The Knowledge to Action Framework ²⁹²:



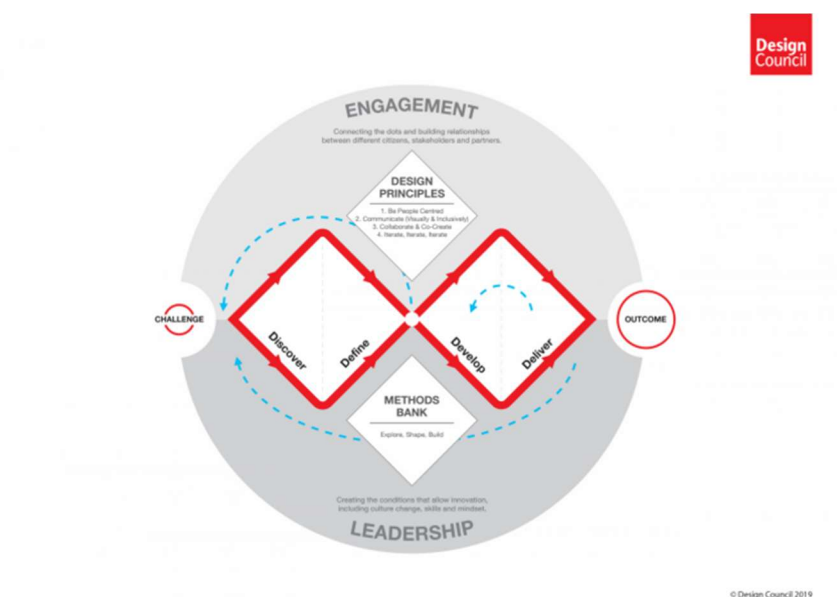
In this research program, patient partners were engaged as consultants in advisory roles. In consultation, interactions are not as intensive as with collaboration where “patients are ‘coresearchers’ involved in all stages of the research process, sharing control and co-labouring

on an equal basis with academic researchers in an ongoing process of dialogue and interaction”²⁹⁶. Consulting with patient-partners provided end-user perspectives on relevant research outcomes, inclusive research designs, and appropriate dissemination strategies, that were incorporated into the research process. This was done to attempt to ensure that the research outcomes were relevant to the end-users.

Design Thinking framework

In addition to using the KTA framework to guide the study processes within this research program, the Design Thinking (DT) framework informed the development and design of the PA intervention. It is becoming more apparent that new interventions cannot be imposed but have to be perceived by end users to have value and make them *feel* better; this makes it imperative for designers of new interventions to develop patient-centred relevant solutions²⁹⁷. The Double Diamond Design Thinking framework developed by the Design Council describes a methodology that incorporates fundamental principles and design methods²⁹⁸.

Figure 4: Double Diamond Design Thinking Framework (used with permission)²⁹⁸



According to the developers, the first diamond depicts a process of exploring a problem in a more detailed manner (divergent thinking) and then coalescing all gathered information to take focused action to solve the problem (convergent thinking). The entire process involves four non-linear stages: discover (understand the problem rather than assume), define the problem, develop (gather varied solutions to the defined problem) and deliver (test different solutions, improve on those that work and discard those that don't work) ²⁹⁸. The Design Thinking framework focuses on peoples' feelings and reactions when they interact with an intervention ²⁹⁷. The DT framework has been used for many years in the business community; however, it is now being increasingly used in healthcare such as in the prevention of infectious diseases and optimizing transfer of information during nurses' shift changes ²⁹⁷⁻²⁹⁹.

This framework may be useful in healthcare because it offers an innovative way to develop solutions and interventions that meet complex needs of individuals within the healthcare system ²⁹⁹. A recent systematic review ³⁰⁰ to ascertain the use of DT and its effectiveness in healthcare, identified 24 studies that used DT. Twelve of the studies demonstrated success of the framework, 11 reported mixed successes and one reported lack of success. Roberts and colleagues ²⁹⁹ argue that most of the frustrations attributable to innovation development within the healthcare system is not a result of lack of vision or resources but from a model or system being required to do what it is not designed to do. They emphasize that the DT framework can help drive the development of innovations that meet complex needs of end users within the healthcare system. Several authors conclude that more studies are needed to fine-tune the critical components of the DT framework and its applications in healthcare innovations ^{297, 300}. The Double Diamond Design Thinking framework was useful in this research program to guide the

development of an intervention that not only supports individuals with quiescent and mildly active IBD, but also ensures they feel valued and heard.

Research Program

Rationale for research program

The rising prevalence of inflammatory bowel disease (IBD), alongside advances in treatment have shifted clinical priorities toward long-term symptom management and quality of life.

Coward et al.⁸ have estimated that there will be > 402,000 Canadians living with IBD by 2030.

With recent major advances in the efficacy of medical therapy to ensure mucosal healing, the majority of those with IBD may be in the quiescent disease phase in future²³. Researchers have thus suggested that future research should focus on alleviating symptom burden in the quiescent

disease phase²³. PA may serve as a helpful adjunct therapy to lessen persistent symptoms in quiescent IBD and enhance quality of life^{6, 32, 126, 301, 302}. Recently, it has been advocated that encouraging regular engagement in PA should be an important component in the management of IBD³⁰³ and it should also be included as part of prevention strategies in high-risk patients³⁰⁴.

WHO²⁶ recommends PA for adults with chronic conditions as PA reduces the rate of disease progression, and improves mental health. Unfortunately, there is low PA participation in the IBD population⁷. Additionally, there are no specific PA guidelines for individuals with IBD¹⁴⁰.

Even though recent studies have attempted to identify the barriers to PA participation among this group, studies eliciting barriers to PA participation with the goal of developing PA programs designed to mitigate those barriers, as well as eliciting their preferences for PA participation are lacking. This research program aimed to bridge this gap by developing a PA intervention tailored specifically to individuals with quiescent IBD, so they might experience the

potential benefits of PA, and consequently, their participation in PA may help alleviate some persistent symptoms of IBD.

Michie et al.¹⁹¹ advised that to design an intervention aimed at increasing PA participation in any population, it is important to have a systematic method that incorporates an understanding of the behaviour to be changed, a system for categorising the intervention and the various components that can make use of this understanding. This research program utilised a systematic method which culminated in the development of a PA program that was adapted for those with quiescent and mildly active IBD. If low PA participation is identified as a behaviour that needs to be changed, the next step for behavioural change is to identify possible causes of the undesired behaviour (correlates of PA participation in those with quiescent IBD) and then determine appropriate strategies (interventions) to reduce the occurrence of the undesired behaviour, using qualitative methods. To determine whether this intervention should go on to a large-scale study for efficacy testing, it is important to perform a feasibility study.

Feasibility studies function to produce a set of findings that determine and/or prioritize the interventions that should be tested for both efficacy and effectiveness in the bid to conserve resources²⁷⁸. It was hypothesized that by the end of this research program, we would have developed a feasible and acceptable PA intervention tailored specifically to individuals with quiescent and mildly active IBD who continue to experience persistent symptoms, and that participation in this PA intervention would reduce the frequency and impact of some persistent symptoms, as well as improve individuals' HRQoL.

Objectives of research program

The overarching purpose of this research program was to develop and assess the feasibility and acceptability of a novel IBD-specific PA program for the management of ongoing symptoms of fatigue, joint pain, abdominal pain, stress, anxiety and depression, and to improve HRQoL in adults (20 - 45 years) with quiescent and mildly active IBD. This thesis had three main aims.

Each aim was fulfilled via individual research studies:

1. Study 1: To determine existing knowledge about the safety and efficacy of PA as adjunct therapy to medical therapy, compared to medical therapy alone for alleviation of ongoing symptoms and improvement in HRQoL in adults with quiescent IBD.
2. Study 2: To explore patient experiences with PA, as well as barriers and facilitators of PA participation among adults (age 20 - 45 years) with quiescent IBD who continue to experience persistent symptoms.
3. Study 3: To investigate the feasibility and acceptability of an individualised PA behaviour change intervention designed for adults (age 20 - 45 years) with quiescent and mildly active IBD for a future large trial.

Overarching hypothesis: We proposed that engaging in a personalized IBD-specific PA program developed from the outcomes of a systematic literature review and studying the PA experiences of people with IBD, will be safe, acceptable, and potentially beneficial for adults with quiescent or mildly active IBD, potentially reducing persistent symptoms and improving health-related quality of life.

Overview of the organization of this thesis

The objectives of this research were achieved by completing three key inter-related research studies. Study 1 fulfilled the first aim via a systematic review and meta-analysis of existing trials. With this study, we synthesized evidence on the safety and efficacy of PA as adjunct therapy to medical therapy, for alleviation of persistent symptoms and improvement in HRQoL in adults with quiescent IBD. In this study, overall safety and efficacy of PA in the IBD population were assessed. Specific types of PA and exercises that address pre-identified persistent symptoms and improved HRQoL were also identified. This manuscript ³⁰⁵ has been published and is presented with permission in Chapter 2.

Having established the safety and potential efficacy of PA as an additional therapeutic strategy in quiescent IBD, we proceeded to the second research objective. This was achieved via a qualitative description study to elicit the perspectives and experiences of adults with IBD on PA participation. We explored the barriers and facilitators of PA participation, as well as the influence of sex and gender on engagement while living with IBD. The goal was to elicit the correlates of PA that are unique to adults with quiescent IBD including barriers to be mitigated in order to promote PA participation in this group. This manuscript has been published ³⁰⁶ and is presented in Chapter 3. In this qualitative study, we also explored patient preferences on the design and delivery of an IBD-specific PA program. This manuscript is not yet published. It is presented in Chapter 4.

The findings of studies 1 and 2 provided data on specific activities and exercises that can be incorporated into an IBD-specific PA program, the possible barriers and facilitators of participation in such a program, including the most suitable method of delivery to enhance ease

of participation, as well as the design components that should go into an IBD-specific PA program. Facilitated by the Double Diamond Design Thinking framework, these data were systematically incorporated to facilitate the design of a behaviour change PA program unique to adults with quiescent and mildly active IBD. The last aim of this research program was achieved by investigating the feasibility and acceptability of this PA program via a pilot non-randomized trial. This manuscript is presented in Chapter 5.

Chapter 6, the final chapter in this thesis, summarizes the overall findings of this research program. Novel aspects of this thesis are described, including associated strengths and limitations. This chapter also discusses the implications of this thesis for clinical practice, future research in this field and health policy.

Of note, the references associated with each manuscript are included at the end of their respective chapters. The reference list at the end of this thesis is associated with chapters 1 (Introduction) and 6 (Discussion and Conclusion).

Chapter 2

Study 1: Physical activity for quiescent and mildly active inflammatory bowel disease - a systematic review and meta-analysis.

Publication Status:

This manuscript³⁰⁵ is published in the Journal of the Canadian Association of Gastroenterology (JCAG). Per the Editor of the JCAG, including this manuscript in this thesis does not require copyright permission as long as the manuscript is referenced. This correspondence is in Appendix I.

Citation:

Oketola, B., Akinrolie, O., Webber, S., Askin, N., Rabbani, R., Abou-Setta, A. M., & Singh, H. (2023). Physical activity for quiescent and mildly active inflammatory bowel disease: a systematic review and meta-analysis. Journal of the Canadian Association of Gastroenterology, 6(5), 162-171.

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Abstract

Background: Physical activity (PA) may benefit people with inflammatory bowel diseases (IBD) by improving immunological response, musculoskeletal function, and psychological health.

Aims: We distilled available evidence on the efficacy and safety of PA to improve health-related quality of life (HRQoL) and relieve persistent symptoms of fatigue, joint pain, abdominal pain, stress, anxiety, and depression in individuals with quiescent/mild IBD.

Methods: We searched for trials in eight databases and trial registries. Trials using PA as an adjunct therapy in the management of adults (≥ 18 years) with quiescent or mild IBD, published in English between 2011 and 2023 were identified. Summary effect estimates were expressed as standardized mean difference (SMD) or mean difference (MD) with 95% confidence interval (CI) using random-effects model.

Results: From the 10,862 citations retrieved, we included seven randomized controlled trials (RCT) and one non-RCT. There was no evidence of benefit of PA on HRQoL (SMD 0.34, 95%CI -0.08 to 0.77; I^2 57%); high heterogeneity was noted among included trials. PA was found to be efficacious in reducing anxiety (SMD -0.35, 95%CI -0.65 to -0.05; I^2 0%). There was insufficient evidence to make conclusions regarding changes in fatigue, joint pain, abdominal pain, stress, and depression. All trials deemed physical activity safe.

Conclusions: PA contributes to reducing anxiety in quiescent/mild IBD. There is marked heterogeneity in methodology among trials investigating PA in adults with quiescent/mild IBD. This review highlights the need for consistent definitions of PA types and intensities in this field of research.

Keywords: Inflammatory Bowel Disease; Physical Activity; Quiescent IBD, Exercise, Systematic reviews; Inconsistent measurement.

Lay Abstract

Some people with inactive or mild inflammatory bowel diseases (IBD) continue to have persistent symptoms. Physical activities including exercise of mild, moderate, and high intensities, as well as resistance training may decrease these persistent symptoms and improve quality of life.

We summarize results of studies comparing increasing or not increasing physical activity among adults with inactive or mild IBD. We include studies published in English between 2011 and 2023.

We found eight studies. These studies used different physical activities and different intensities. Physical activity decreased anxiety among people with inactive or mild IBD. The difference in methods of studies makes it impossible to figure out the amount of benefit of increased physical activity, on different persistent symptoms and quality of life in those with inactive and mild IBD.

Introduction

Inflammatory bowel disease (IBD) is a chronic inflammatory condition of the gastrointestinal tract comprising two main forms: Crohn's disease (CD) and ulcerative colitis (UC) ¹. IBD is a lifelong condition with no cure and can be associated with substantial long-term morbidity ^{2,3}. Intestinal manifestations of IBD include abdominal pain, diarrhea, malabsorption of nutrients, and gastrointestinal blood loss ^{4,5}. Extraintestinal manifestations, which affect 25% of patients ⁶ include fatigue, joint pain, erythema nodosum, iritis and uveitis, low bone mineral density and

loss of muscle mass ^{7,8}. Although the symptom burden is worse during periods of active mucosal inflammation, many symptoms persist after individuals achieve remission ⁴.

While most of the focus has been on the management of the active disease phase in IBD, with recent major advances in management of active IBD, burden of symptoms in quiescent disease needs more attention ⁹. Medical therapy for management of quiescent IBD targets prevention of active inflammation and aims to delay/inhibit relapses ¹⁰. However, several studies have shown that individuals with quiescent IBD report physical symptoms including fatigue, abdominal pain, and joint pain; and psychological symptoms including stress, anxiety, and depression ^{7, 11-17}. These persisting symptoms impact health-related quality of life (HRQoL) ^{1, 9, 16}, and have cost implications for health care. Consequently, individuals with IBD continue to seek adjunct therapies ^{10, 18}.

Previous research suggests that PA could be an adjunct therapy to help reduce ongoing symptoms in quiescent IBD and improve HRQoL ^{1, 10, 18-20}. The World Health Organization (WHO) defines PA as “any bodily movement produced by skeletal muscles that requires energy expenditure...including movement during leisure time, for transport to and from places, or as part of a person’s work” ¹⁹. Exercise, as defined by the WHO, is a “subcategory of physical activity that is planned, structured, repetitive, and purposeful in the sense that the improvement or maintenance of one or more components of physical fitness is the objective” ¹⁹. In this review, we use physical activity as an encompassing term to refer to all forms of musculoskeletal activities including exercise.

PA may counteract some IBD-specific complications by improving immunological response and psychological health, and by reversing the decrease in muscle mass and strength ¹¹. However, there is a lack of estimate on magnitude of PA’s efficacy, its acceptability and safety

among individuals with IBD. This may contribute to why a large proportion of individuals with IBD do not participate in PA at recommended levels ²¹.

We performed a systematic review and meta-analysis to distil the evidence on the efficacy of PA to reduce symptoms in quiescent/mild IBD.

Our specific objectives were:

1. To identify, critically appraise, and summarize available evidence on the efficacy of PA as an adjunct therapy to improve HRQoL and reduce symptoms of fatigue, joint pain, abdominal pain, stress, anxiety, and depression among individuals with quiescent or mildly active IBD.
2. To assess the safety of, and adherence to, PA as an adjunct therapy in the management of quiescent or mildly active IBD.

Methods

We followed review guidelines detailed in the Cochrane Handbook for Systematic Reviews of Interventions ²² and report according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) ²³. The PROSPERO registration ID is CRD42022298310.

Criteria for selection of studies for review - Inclusion and Exclusion Criteria:

We included randomized controlled trials (RCTs) and non-randomized/non-controlled trials (non-RCTs) involving adults with quiescent or mild IBD, where any form of PA was used as an intervention in conjunction with usual care (medical therapy or no therapy). We decided to include non-RCTs to increase the number of eligible citations to strengthen our review. Our primary outcome was HRQoL. Secondary outcomes were fatigue, abdominal pain, joint pain,

stress, anxiety, depression, safety of PA and adherence. Only studies published in English, between 2011 and 2023 were included.

Search Strategy:

The search strategy was developed initially in MEDLINE (Ovid) by an information specialist (NA) and peer-reviewed by a second librarian using the PRESS (Peer Review of Electronic Search Strategies) checklist ²⁴. The final search strategy was translated and run in EMBASE (Ovid), Cochrane CENTRAL (Ovid), PsycInfo (Ovid), CINAHL (EBSCO), Scopus (Elsevier), Web of Science Core (Clarivate), and PEDro (web) (Supplementary Data). We searched for ongoing studies by reviewing trial registries (e.g., ClinicalTrials.gov). The most recent search was performed on 10th January 2023.

We performed a hand search of the reference lists of eligible citations and conference proceedings (2016 to January 2023) of Digestive Diseases Week, Canadian Digestive Diseases Week, World Physiotherapy Congress, and Canadian Physiotherapy Association Congress. Lastly, we screened the first 10 pages of results in Google Scholar using the search string exercise|”physical activity” ibd|”inflammatory bowel”|crohns|colitis. All citations obtained from the literature search were exported to EndnoteTM (version 20, Clarivate) for reference management and deduplication. Relevant citations were imported into Rayyan ²⁵ for study selection.

Study Selection:

Identification of eligible citations was carried out independently by two reviewers (BO and OA/SW) and was conducted in two stages – title/abstract and full-text screening. Prior to commencement of citation screening, both reviewers pilot tested the eligibility criteria on 10

randomly selected titles to ensure the eligibility criteria were clear and consistently applied. Studies including other interventions in addition to PA were excluded (except when the intervention was given to all study groups equally). All conflicts that arose were resolved by discussion among the primary reviewers. When there was no resolution after discussion, a third reviewer (AMAS and/or HS) was consulted.

Data Processing and Management:

A Microsoft Excel data extraction form developed using the DECiMAL guide ²⁶ was used for data extraction. Two reviewers (BO and OA) independently carried out data extraction. The data extraction form was pilot tested on two of the eligible studies to ensure the form captured all essential components needed to satisfy the research objective. The form was used to collect author/year, demographic information of participants, number of participants, type of intervention used, primary and secondary outcomes, as well as the outcome measures used. Disagreements were resolved by discussion.

Risk of Bias Assessment and Methodological Quality:

Risk of bias (RoB) of included RCTs was assessed using the Cochrane Risk of Bias tool (version 1) for RCTs ²². The study quality of the non-RCT was assessed using the Newcastle-Ottawa scale (NOS) ²⁷. All assessments were conducted independently by two reviewers (BO and OA). Conflicts were resolved by discussion or consultation with a third reviewer (AMAS).

Data Analysis:

We analysed data collected from included trials using Review Manager (RevMan) version 5.4. Summary effect estimates were expressed as standardized mean difference (SMD) (when studies used different outcome measures) or mean difference (MD) (when studies used same outcome

measures) with 95% confidence interval (CI) using random-effects model. The sample size and means/SD for three-armed studies were combined prior to analysis. Heterogeneity was quantified using the I^2 statistic. Source of heterogeneity was explored when I^2 was found to be greater than 50%, after confirming accuracy of the extracted data ²². Due to the limited data identified, we were unable to perform subgroup analysis by sex, IBD diagnosis (CD or UC), and intensity of PA (mild, moderate, or vigorous), which was planned a-priori. We retrieved missing data from tables, figures, supplemental materials, and we contacted authors to get additional data and clarification. Publication bias could not be assessed due to the small number of included trials.

Quality of Evidence:

We assessed quality of the evidence using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) for each outcome ²⁸. We rated the evidence as 'high', 'moderate', 'low' or 'very low' certainty in accordance with this approach.

Results

From 10,862 retrieved citations, we included seven RCTs ²⁹⁻³⁵ and one non-RCT ⁵ that met the inclusion criteria (Figure 1). Descriptive information of included studies is presented in Table 1.

Tew et al. ³⁰ used high intensity interval training (HIIT) and moderate intensity continuous training (MICT) as PA interventions. Authors measured intensity of leg cycle ergometry using 'peak power output' (W_{peak}) with 90% W_{peak} for HIIT and 35% W_{peak} for MICT. Jones et al. ³¹ utilized resistance training as their PA intervention. They had a target intensity of 'moderate to hard' for resistance training intervention which was assessed by the Resistance Intensity Scale for Exercise outcome measure. Klare et al. ²⁹ utilized moderate intensity for their running intervention which was defined as being able to talk while running.

Seegar et al.³² also utilized moderate intensity which was defined as 60 - 80% of maximum heart rate. They had one group performing resistance training and the second group performing aerobic exercises. The authors^{33,34} who used yoga as PA intervention did not mention intensity. Due to the variability in the types of PA and in the definitions used to describe intensity of PA in these trials, we were not able to assess the type and intensity of PA that is more beneficial for individuals with IBD.

Risk of Bias Assessment and Methodological Quality:

RoB summary of RCTs is presented in Figure 2. All RCTs were rated as having an overall unclear to high risk of bias. Masking of participants to treatment allocation was not possible in all the trials due to the nature of the intervention. In most trials, participants were their own outcome assessors, however, three trials^{30,31,33} reported masking of assessors. Masking of outcome assessment was not reported in one trial²⁹. Loss to follow-up was minimal in most trials except one³² with moderate loss to follow-up, suggesting attrition bias. Published protocols were not available for four of the trials³²⁻³⁵, thus there is possibility of bias due to selective reporting.

The included non-RCT⁵ scored 5 stars out of a possible 9 stars. It was given a score of 3 stars for selection, no star for comparability and two stars for outcome, with possibility of bias resulting from lack of controlling for covariates.

Primary Outcome

Our initial analysis revealed there was no evidence of benefit of PA on HRQoL (SMD 0.34, 95% CI -0.08 to 0.77; I^2 57%, 6 RCTs, 235 participants; very low certainty evidence). Due to the substantially high I^2 , heterogeneity was explored. The trial by Seegar et al.³² was observed to be an outlier with an opposite effect compared to the other trials in the analysis. They used the

short-form of the Inflammatory Bowel Disease Questionnaire (IBDQ) while other trials used the full IBDQ and SF-36. We performed a subgroup analysis based on outcome measures (short vs. long versions). This analysis revealed a significant difference in the effect of PA on HRQoL in studies that used the full versions of the outcome measures (SMD 0.51, 95% CI 0.22 to 0.79; I^2 0%, 5 RCTs, 200 participants; moderate certainty evidence) (Figure 3).

The non-RCT included in this review ⁵ investigated the effect of an aerobic and resistance training program delivered for 60 minutes, 3 times/week for 12 weeks on HRQoL. Using the IBDQ, they reported a statistically significant improvement in HRQoL from 156 ± 21 to 176 ± 19 , with change score of 20 ± 4.47 .

Secondary Outcomes:

Fatigue: Two trials ^{30, 31} evaluated the effect of PA on fatigue and both used the IBD Fatigue Scale as outcome measure. High heterogeneity was found between the two studies ($I^2 = 87\%$, Figure 5, Supplementary Data), thus meta-analysis was not performed.

Tew et al. ³⁰ in their pilot trial assessed the effect of HIIT and MICT over 12 weeks. After 12 weeks of HIIT, fatigue increased from 8.2 ± 3.0 to 8.3 ± 3.2 but reduced to 7.5 ± 2.5 after another 12 weeks of follow-up. In the MICT group, fatigue increased from 7.8 ± 5.3 to 8.3 ± 4.9 after 12 weeks of intervention, but also reduced to 7.3 ± 4.2 after another 12 weeks of follow-up. In the control group, fatigue scores reduced from 9.3 ± 4.1 at baseline to 7.8 ± 4.2 at 12 weeks and to 7.5 ± 4.0 after another 12 weeks of follow-up.

Jones et al. ³¹ assessed the effect of moderate-high intensity resistance training. They reported a statistically significant reduction in fatigue from 6 ± 4 to 5 ± 3 after 24 weeks of intervention ($p = 0.03$), while fatigue in the control group increased from 9 ± 4 to 10 ± 5 .

The non-RCT⁵ reported that following a 12-week intervention of aerobic and resistance training, fatigue in individuals with quiescent IBD reduced from 49 ± 4.7 to 29 ± 8.9 [MD -20, 95% CI: -16 to -24].

Anxiety: There was a significant decrease in anxiety with PA (SMD -0.35, 95% CI -0.65 to -0.05; I^2 0%, 4 RCTs, 178 participants: low certainty evidence) (Figure 4).

Depression: The meta-analysis on this outcome identified moderately high heterogeneity (I^2 54%, 3 RCTs, 127 participants). All studies used the Hospital Anxiety and Depression scale (HADS) as an outcome measure. No individual factors could be identified to delineate the three studies to justify a subgroup analysis.

Tew et al.³⁰ reported a reduction in depression scores from 3.6 ± 3.1 to 2.7 ± 1.7 following 12 weeks of intervention in the HIIT group, and from 3.8 ± 2.9 to 2.7 ± 3.3 in the MICT group. Cronin et al.³⁵ reported an increase in depression scores from 1.71 ± 2.8 to 2.28 ± 3.3 after 8 weeks of combined aerobic and resistance training, and a change from 4.71 ± 4.6 to 4.14 ± 4.5 in the control group. Cramer et al.³³ reported a statistically significant reduction in depression from 6.1 ± 3.9 at baseline to 4.5 ± 2.9 after 12 weeks of yoga in the intervention group; and 6.5 ± 3.0 to 6.9 ± 4.0 in the control group, with a group difference of 2.3 (1.0; 3.7) at 95% CI.

Joint pain, stress and abdominal pain: One of the included trials³⁴ investigated the effect of PA on joint pain. Ten out of 25 participants reported joint pain at baseline: five and three reported joint pain after 4 weeks and 8 weeks of yoga, respectively. In the control group, five out of 26 participants reported joint pain at baseline, six and five reported joint pain at 4 weeks and 8 weeks respectively.

Cramer et al.³³ reported a reduction in perceived stress (Perceived Stress Questionnaire) from 50.0 ± 16.7 to 42.1 ± 18.7 in the yoga group compared to a reduction from 56.9 ± 14.7 to 54.8 ± 19.0 in the control group with a group difference of 7.8 (1.0; 14.6) at 95% CI, following 24 weeks of follow-up.

None of the included studies reported on abdominal pain.

Safety and Adherence: The safety of PA was determined by the number of participants reported to experience adverse events during the intervention period. Reported adverse events from all eight trials include complaints of dizziness, nausea, and light headedness ($n = 9$), any new diagnosis ($n = 2$), and increased IBD activity ($n = 7$). There was no evidence of more individuals having adverse effects due to PA (Risk ratio 2.07, 95% CI 0.7 to 5.49; I^2 0%; 7 RCTs, 174 participants).

Adherence was determined by the rate of attendance at PA sessions. The reasons reported for missing PA sessions included work-related tiredness, holidays, other commitments, joint discomfort, illness, bad weather, and lack of motivation. Adherence rates ranged from 47% to 87% (average of 69% across all studies). The location of PA (gym, home or outdoors) did not seem to influence adherence rates (Table 2).

Discussion

This systematic review identified seven RCTs and one non-RCT with a total of 300 participants. Therefore, there is a limited amount of RCT level research evaluating PA in mild/quiescent IBD. The PA interventions evaluated included yoga, moderate and high intensity aerobic exercises, and resistance training. The most common duration of intervention was 12 weeks. Pooled results of trials suggested that PA may be beneficial in improving HRQoL in those with quiescent/mild

IBD (moderate certainty evidence), although one trial which used a different, though validated outcome measure (sIBDQ), found the opposite effect and hence more data are required. PA was found to be efficacious in alleviating anxiety (low certainty evidence). There were inconclusive data with regards to benefit of PA on fatigue, depression, stress, joint pain, and abdominal pain. Results from studies in this review suggests PA is safe for individuals with quiescent/mildly active IBD, with average adherence rates of 69%.

PA has been reported to be an important complimentary therapy in the management of diverse chronic conditions³⁶⁻⁴² and in the management of IBD^{11, 43, 44}. However, findings of our review demonstrate that the marked heterogeneity in current trials make it challenging to determine if there are consistent beneficial effects of PA for individuals with quiescent/mild IBD. This lack of clarity may be responsible for the poor PA participation reported among individuals with IBD^{45, 46}. Available trials on this subject have employed different types of PA and intensities of PA, making the determination of effect size of the efficacy of PA difficult.

To the best of our knowledge, there is no recent similar systematic review on the effect of PA on persistent symptoms in quiescent/mild IBD. Previous reviews were either not recent⁴⁷ or included trials published prior to the recent advances in medical therapies⁴⁸. While narrative reviews⁴⁹ may come to similar conclusions as systematic reviews, they lack the same level of methodological rigor, or transparency.

There are barriers to participating and adhering to an exercise regimen in the general population and people with IBD face additional obstacles, related to persistent symptoms, which affect their ability to take part in PA^{14, 50, 51}. This further emphasizes the importance of standardized definitions to ensure consistency in trials on PA in the IBD population.

While we conducted a systematic review using standard methodological practice, there were notable limitations. The variability in the included studies and inability to perform subgroup analysis by sex, specific diagnosis, type of PA, and intensity represent limitations. Secondly, none of the included studies used objective measures to assess amount of PA, and participation in PA could not be objectively verified. It is also important to highlight that PA participation in these studies will be by individuals who already value the benefits of PA. This introduces selection bias to the included trials. Furthermore, since participants of included studies could not be blinded to their interventions, participants may have reported more positive outcomes on their subjective assessments. The time limit applied to eligible studies may have contributed to the limited data obtained in our review. However, this time limit is relevant to focus on PA effect in the context of recent advances in medical therapy on disease processes for IBD.

This review is relevant in that it contributes to emerging literature on the efficacy and safety of PA in the IBD population. It emphasizes the marked methodological heterogeneity in available trials, and the need for more RCTs to make more definitive conclusions on the efficacy of PA as an adjunct therapy in quiescent/mild IBD.

Conclusions:

There remains limited evidence to assess the efficacy of PA to improve HRQoL and manage specific persistent symptoms in quiescent or mild IBD. Rigorous and larger RCTs are needed to provide evidence-informed recommendations to individuals living with IBD.

Acknowledgement

The authors acknowledge the contributions of Dr. Hansen, Dr. Shaffer and a patient-partner in helping to identify relevant outcomes and shaping the research question.

Funding:

This work was supported by the Canadian Association of Gastroenterology PhD Studentship award. The funding organization had no role in the conduct of the review or the decision to publish the results.

Competing interests:

Dr. Singh has been on advisory boards or consulted to Pendopharm, Ferring Canada, Amgen Canada, Roche Canada, Sandoz Canada, Takeda Canada, Bristol-Myers Squibb Canada and Guardant Health, Inc. Other authors declare they have no financial competing interests.

Data Availability:

The data underlying this article are available in the article and in its online supplementary material.

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Table 1: Characteristics of included trials.

Author/Year	Mean age ± SD	Total participa nts	Diagnosis . Disease Severity.	Definition of Disease activity	PA intervention	Authors' description of intensity	Control group	Intervention duration	Duration Frequency of PA
Cramer et al., 2017 (36)	Not reported	77	UC Quiesc.	Rachmilewitz clinical activity index ≤ 4	Yoga (Exercise class =1/week Home = daily).	Not defined	Medical Therapy	12 weeks	45 min Daily
Cronin et al., 2019 (38)	32.6 ± 3.0	14	IBD Quiesc.	'Low scores' Simple Colitis index = 1.5 (1, 2.75) Harvey Bradshaw Index = 1 (0, 1.5)	Aerobic and resistance training (with machines/free weights)	Mod intensity defined as 5-7 out of 10 on Borg RPE	Usual care	8 weeks	Not reported 3 days/week
Jones et al., 2020 (34)	46.1 ± 11.9	47	CD Quiesc.+	Calprotectin <250 µg/g CDAI < 150 CDAI = 150 - 219	Resistance training (squats, lunges, rope-skipping using body weight and Theraband for resistance)	Mod to high intensity self-rated with Resistance Intensity Scale for Exercise	Medical Therapy	26 weeks	60 mins 3 days/week
Klare et al., 2015 (21)	41.1 ± 14.1	30	IBD Quiesc.+	CDAI <220 Rachmilewitz Index < 11 points	Running program (Outdoors)	Mod intensity defined as being able to talk while running	Medical Therapy / No therapy	10 weeks	Not reported 3 days/week
Seegar et al., 2020 (35)	45.3 ± 12.4	45	CD Quiesc.+	CDAI < 220	Grp 1-Resistance training (push ups, sit-ups). Grp 2- Aerobic Ex (jogging, cycling)	Mod intensity rated with Borg RPE and set at 60-80% of HRmax.	Medical Therapy	12 weeks	30 - 40 mins 3 days/week
Sharma et al., 2015 (37)	Not reported	44	IBD Quiesc.	Truelove and Witts = Mild CDAI < 150	Yoga	Not defined	Medical Therapy	8 weeks	60 mins Daily
Tew et al., 2019 (33)	37.0 ± 11.1	36	CD. Quiesc.+	Calprotectin <250 µg/g CDAI < 150 CDAI = 150 - 219	Leg cycle ergometer: Grp 1- HIIT= 1 min x 90% + 1 min x 15%	Peak Power Output (Wpeak) - determined for each individual at baseline.	Medical Therapy	12 weeks	~ 30 mins 3 days/week

					Wpeak for 20 minutes. Grp 2-MICT= 30 min x 35% Wpeak.				
Van Erp et al., 2021 (7)	45 ± 2.6	25	IBD Quiesc.	Calprotectin < 100	30 mins aerobic ex (cycling, treadmill) + 30 min resistance training with machines	Intensity for aerobic training set at 65-80% of HRmax.	Medical Therapy	12 weeks	60 mins 3 days/week

Quiesc. = Quiescent. Quiesc+ = Quiescent + Mildly active. Grp 1 = Group 1. Grp 2 = Group 2.

Table 2: Safety and adherence of Physical activity in the included trials

Author/Year	# Ppts	Diagnosis	Supervision (Group vs. Indiv. training)	Intervention Duration	Loss to f/u (Intervention)	Adherence (Location)	Safety (# of participants with reported AE)	
							PA	No-PA
Cramer et al., 2017	77	UC	Supervision provided at exercise class Group + Indiv.	12 weeks	12	60.8% (Ex class)	3	1
Cronin et al., 2019	14	IBD	Supervised (Not specified)	8 weeks	1	87.5% (Gym)	1	1
Jones et al., 2020	47	CD	12 out of 78 sessions were supervised. (Not specified)	26 weeks	1	62% (Gym)	3	2
Klare et al., 2015	30	IBD	Supervised (Not specified)	10 weeks	3	80% (Outdoors)	1	0
Seegar et al., 2020	45	CD	Not supervised (Individual)	12 weeks	2	47% (Home)	2	0
Sharma et al., 2015	100	IBD	Supervised 1 of 8 weeks. Unsupervised 7 of 8 weeks. (Individual)	8 weeks		78.5% (Home)	0	0
Tew et al., 2019	36	IBD.	Supervised (Not specified)	12 weeks		HIIT = 62% MICT = 75% (Ex class)	4	
Van Erp et al., 2021	25	IBD	Supervised (Group)	12 weeks	3	Not Reported (Gym)	1	N/A

Ppts = Number of Participants. Indiv. = Individual

Table 3: GRADE Assessment of the quality of evidence in included trials.

Question: PA compared to medical therapy/usual care for IBD

Setting: Clinical setting

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	PA	Medical therapy/usual care	Relative (95% CI)	Absolute (95% CI)		

Health related quality of life (assessed with: SIBDQ, SF-36)

6	randomised trials	very serious ^a	not serious	not serious	serious ^b	none	130	105	-	SMD 0.34 SD higher (0.08 lower to 0.77 higher)	⊕○○○ Very low	CRITICAL
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Certainty of evidence was graded down due to imprecision (small sample sizes) and methodological limitations (lack of blinding of outcome assessors in most studies and possible attrition bias in one of the studies).

Anxiety (assessed with: HADS)

4	randomised trials	serious ^c	not serious	not serious	serious ^d	none	96	82	-	SMD 0.35 SD lower (0.65 lower to 0.05 lower)	⊕⊕○○ Low	
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Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	PA	Medical therapy/usual care	Relative (95% CI)	Absolute (95% CI)		

Certainty of evidence was graded down by two levels due to study limitations (two of the studies had an overall unclear risk of bias and one had an overall high risk of bias) and imprecision (two of the studies had small sample sizes)

HQoL-sensitivity analysis (assessed with: SIBDQ, SF-36)

5	randomised trials	serious	not serious	not serious	not serious	none	108	92	-	SMD 0.51 SD higher (0.22 higher to 0.79 higher)	⊕⊕⊕○ Moderate	
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Bibliography:

CI: confidence interval; **MD:** mean difference; **SMD:** standardized mean difference

Explanations

- 50% of the studies are judged to be of high risk of bias
- the lower boundary of the CI is negative and crosses the line of no effect
- two of the studies are unclear and one high risk of bias
- small sample size
- some level of heterogeneity
- small sample size from the studies

Figure 1: PRISMA Flow Diagram (Summary of literature review and screening process)

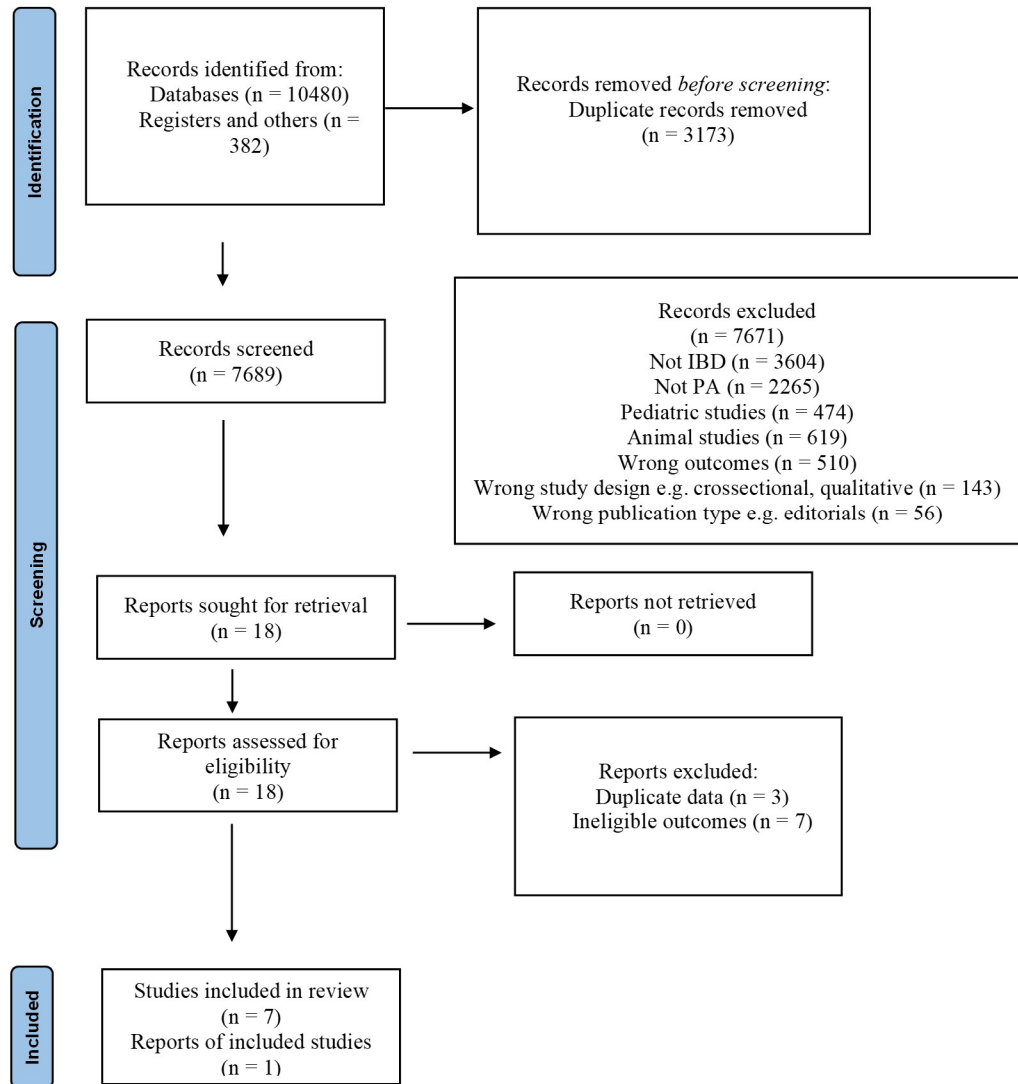


Figure 2: Risk of Bias summary.

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Cramer 2017	+	+	?	+	+	+	+
Cronin 2019	+	+	?	?	+	+	+
Jones 2020	+	+	?	+	+	+	+
Klare 2015	+	+	?	-	?	+	+
Seegar 2020	+	+	?	-	+	-	+
Sharma 2015	+	+	?	-	+	?	+
Tew 2019	+	+	?	+	+	+	+

Figure 3: Sub-group analysis on effect of PA on HRQoL (short vs. long form outcome measures)

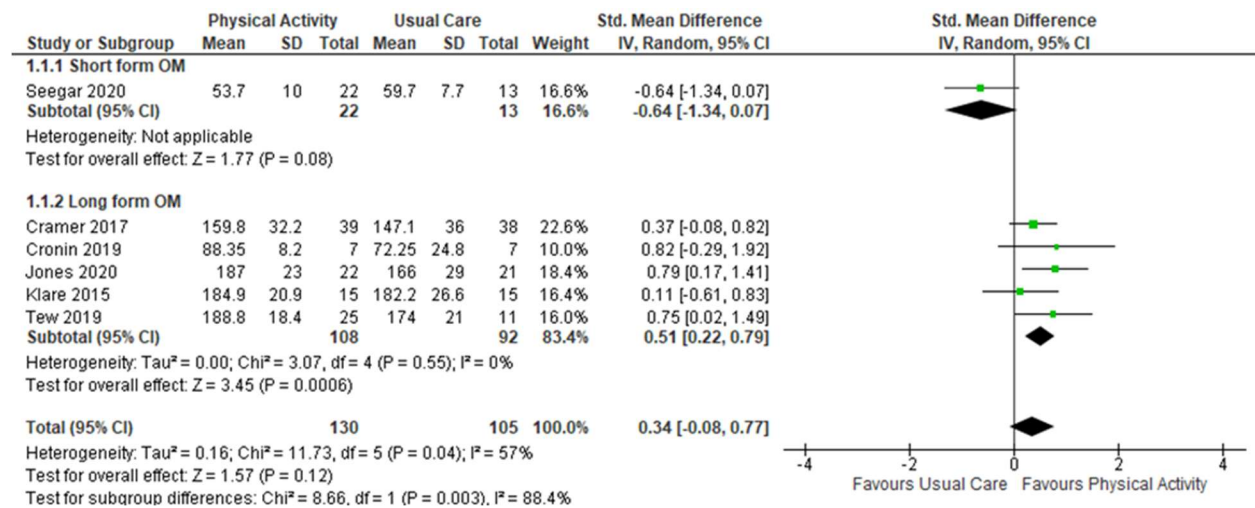
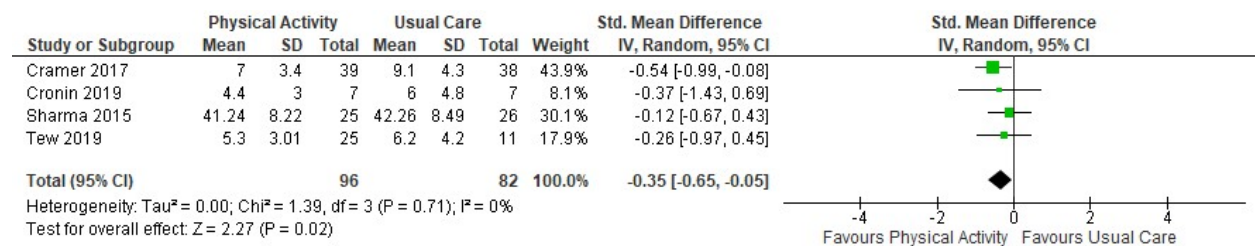


Figure 4: Effect of PA on anxiety



Chapter 3

Study 2: Behaviour change considerations to improve physical activity participation among individuals with quiescent IBD – barriers and facilitators.

Publication Status:

This manuscript is published in *Advances in Rehabilitation Science and Practice Journal* ³⁰⁶. It was submitted for publication on 27th May 2025 and accepted on 9th September 2025. Per the open access publication license, this manuscript can be included in this thesis as long as it is properly cited (Appendix II).

Citation:

Oketola, B., Webber, S., Singh, H., Kredentser, M., Reynolds, K., & Restall, G. (2025).

Behaviour Change Considerations to Promote Physical Activity Participation among Individuals with Quiescent Inflammatory Bowel Disease: Barriers and Facilitators. *Advances in Rehabilitation Science and Practice*, 14, 27536351251382074.

<https://doi.org/10.1177/27536351251382074>

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Abstract:

Background: Most individuals with Inflammatory Bowel Diseases (IBD) do not engage in optimum levels of physical activity (PA). This study aimed to identify important factors to consider when promoting PA participation among individuals with quiescent or mildly active IBD.

Methods: In this qualitative description study, we purposively enrolled 15 Manitobans with quiescent IBD. Data was collected via semi-structured interviews conducted on Zoom. Using the Capability, Opportunity, Motivation and Behaviour (COM-B) model, we elicited factors that influence PA behaviour. We performed thematic analysis of transcribed interviews using NVivo.

Results: Participants' (N = 15) ages ranged between 20 – 37 years, majority were female (n = 8), and most had a diagnosis of Ulcerative Colitis (UC) (n = 10). None was a current smoker.

Thematic analysis identified persistent symptoms, PA engagement prior to IBD diagnosis, PA routine, coping strategies and determination as themes that influenced 'capability' for PA participation. Social support, type of employment, bathroom access, and finances influenced 'opportunity'. Awareness of the benefits of PA on IBD, relevant knowledge, social support, and personal goals promoted 'motivation' for PA participation. Sex differences were noted in participants' perspectives related to safety concerns and the social context of workout spaces.

Conclusion: Using the COM-B model, we elicited barriers (including IBD-related persistent symptoms, lack of knowledge of PA) and facilitators (social support, coping strategies, ability to track PA progress) that influence PA behaviour among adults with quiescent IBD. These factors are important considerations when promoting PA participation among individuals with IBD.

Key words: Inflammatory Bowel Diseases, Quiescent IBD, Physical Activity Participation, Behaviour Change, COM-B Model

Introduction

Inflammatory Bowel Disease (IBD) refer to remitting and relapsing inflammatory conditions of the gastrointestinal (GI) tract.¹ IBD usually presents as either Crohn's disease (CD) where the inflammation can be anywhere from the mouth to the anus, or as Ulcerative colitis (UC) where the inflammation is in the large bowel only.² IBD is a lifelong condition characterized by periods of active inflammation requiring medical and/or surgical therapies to relieve acute symptoms and achieve mucosal healing; and periods of inactive disease (i.e., quiescent disease) requiring regular maintenance medical therapies.^{1,3} Even though the disease burden is worse during periods of active disease, individuals with quiescent IBD, i.e., IBD in remission, frequently report a number of physical and psychological symptoms.³ Physical symptoms often include fatigue, abdominal pain, joint pain; and psychological symptoms can include depression, worry, stress and anxiety.⁴⁻⁸ Extraintestinal manifestations of IBD, which include arthritis, erythema nodosum, iritis and uveitis, low bone mineral density and loss of muscle mass, can affect up to 25% of patients.^{9,10} Additionally, IBD drug therapies can cause side effects leading to some persistent symptoms.¹¹ For example, prolonged prednisone use can lead to a higher chance of developing osteoporosis, with consequent joint pain, osteoporotic fractures and muscle weakness.^{10,12} Due to ongoing symptoms, individuals with quiescent IBD continue to seek adjunct therapies in addition to medical therapies to manage their disease and improve their quality of life (QoL).^{1,13}

Physical activity (PA) and exercise have been used as a form of adjunctive therapy for a variety of chronic diseases.^{14,15} The World Health Organization (WHO) defines PA as “any

bodily movement produced by skeletal muscles that requires energy expenditure and can be performed at a variety of intensities, as part of work, domestic chores, transportation or during leisure time, or when participating in exercise or sports activities”.^{16(p15)} Exercise on the other hand, is defined by WHO as a “subcategory of physical activity that is planned, structured, repetitive, and purposeful in the sense that the improvement or maintenance of one or more components of physical fitness is the objective”.^{16(pVI)} In this study, we use PA generally to encompass all activities that can be engaged in to improve fitness, flexibility and cardiorespiratory endurance, such as structured exercise, walking, yoga, swimming, etc. The WHO recommends that adults 18 – 65 years perform 150-300 minutes of moderate to vigorous intensity PA to gain substantial health benefits.

In IBD, several studies have highlighted that PA could be a potential adjunct therapy to medical therapy to help reduce ongoing symptoms in quiescent disease state and improve quality of life (QoL).^{3, 8, 14, 17, 18} PA has been recommended because it may improve immunological response, counteract some IBD-specific complications, including reversing reductions in muscle mass and bone mineral density, as well as reduce anxiety and fatigue.^{3, 19, 20} However, despite the potential benefits of PA, a large proportion of individuals with IBD do not regularly participate in PA or meet PA guidelines set out for individuals with chronic conditions.¹⁹

It may be challenging to encourage people with quiescent IBD to engage in optimal levels of PA because it is a complex behaviour change that involves significant commitment, complicated by ongoing symptoms, and lack of knowledge of the benefits of specific types of PA.²¹⁻²³ Additionally, there are no PA recommendations or guidelines for IBD.^{24, 25} Furthermore, a few cross-sectional studies investigating PA engagement among adults with IBD report higher PA engagement among males compared to females.²⁶⁻²⁸ Even though there are a

number of papers investigating the effects of different forms of PA in the IBD population,^{8, 14, 29} and those highlighting the value of PA for members of this group,^{17, 24, 30} there is a scarcity of research exploring the barriers to PA participation and potential facilitators of participation, from the patient perspective. Eliciting the perspectives of individuals with IBD, their experiences with PA and factors that influence participation, such as socioeconomic parameters and correlates of PA, including employment, age, sex, gender and smoking status, may provide relevant information necessary to understand PA behaviour, and factors that influence behaviour change among individuals with quiescent IBD. This is important to design or plan functional and effective PA programs that increase PA engagement among individuals with quiescent IBD.²²

The purpose of this study was to explore patient experiences with PA, so as to elicit the factors that influence PA participation among adults aged 20 - 45 years with quiescent IBD who continue to experience persistent symptoms. Our primary objective was to explore the experiences of PA participation among a sample of adults living with quiescent IBD to elicit the factors that influence their PA participation. The secondary objective was to explore the sex differences in perspectives and preferences for PA among individuals with quiescent IBD.

Materials and Methods

Study Design:

This was a qualitative description study.³¹ Even though we utilized a qualitative description approach, we employed some degree of interpretation at the level of data analysis and data interpretation.³² To be transparent with our analytical processes, we define our theoretical approach, lens and assumption.

Theoretical Framework:

The Capability, Opportunity, Motivation and Behaviour (COM-B) model suggests that a voluntary behaviour (B) is dependent on the presence of capability (C), opportunity (O) and motivation (M); and the occurrence of the behaviour (B) in turn influences the three conditions.³³ Capability can be defined as the extent of someone's ability or the power to do something, and is both physical and psychological.³⁴ Opportunity, which can be both physical and social, refers to a favourable set of circumstances.^{34,35} Motivation, on the other hand, is a complex psychological process that focuses on achieving pre-set goal(s), including both the initiation and maintenance of efforts to achieve the goal(s).³⁶ As explained by Michie and colleagues,³⁵ for an individual to perform a target behaviour (B) at any given time, they must possess the physical and psychological capability (C) to do so, be armed with social and physical opportunities (O) and possess automatic and reflective motivation (M) to follow through, i.e., they must want to perform that behaviour more than any other behaviour in that moment. In this study, performing at least 150 minutes of moderate to vigorous PA was the target behaviour or desired behaviour.

Philosophical Assumptions:

We utilized the constructivist paradigm in this study. This paradigm posits that realities are the products of interactions of the human with the real world, thus knowledge generation must be approached from multiple perspectives.³⁷ To establish the validity of our study results, we used the participant lens, which focuses on checking that the participants' realities are accurately represented in the final account (e.g., member checking).^{37,38}

This study was approved by the University of Manitoba Health Research Ethics Board. All participants provided signed informed consent. We performed our reporting according to the Consolidated Criteria for reporting qualitative research (COREQ).³⁹

Study population:

Participants for this study were Manitobans, 20-45 years, with quiescent IBD. The experiences adults have can be quite different from those of adolescents and older adults. And these differences may influence the way they experience IBD and incorporate PA into their lives. The age limit was applied to reduce participant variance; thus, we focused on the peak age group of IBD onset. Only those who have not had active disease in the preceding six months but had at least one of the persistent symptoms of interest - abdominal pain, joint pain, fatigue, stress, anxiety and depression, despite remission were eligible. Due to COVID social distancing protocols that were still in place, all interviews were completed via videoconferencing. Therefore, all eligible participants were required to have access to supports for videoconferencing. All participants provided signed informed consent.

Participant recruitment:

We recruited participants via maximum variation purposive sampling based on age, gender and IBD diagnosis. This sampling technique is aimed at intentionally selecting individuals with similar characteristics but different, individually nuanced experiences that are relevant to fulfill the study objectives.⁴⁰ Participants ages 20 – 45 years old with CD or UC in remission for at least six months, were recruited from a large teaching hospital, gastroenterology clinics in the community, and through the Crohn's and Colitis Canada-Manitoba Chapter. We acknowledge that it may be impossible to achieve saturation wholly;⁴¹ however, we wanted to approach the decision on when to stop data collection in a systematic manner. To ensure we obtained robust data to achieve study objectives within research resources, we followed the recommendations of Francis and colleagues⁴² for establishing study-specific data saturation. The research team contacted N = 22 potential participants via telephone. Seven were not enrolled due to scheduling conflicts or not meeting eligibility criteria. We purposively enrolled five male and five female

participants as our initial analysis sample. We performed data analysis to identify new information and shared meanings. Upon confirming that we continued to obtain new information in the data, we continued participant enrolment in increments of 2, while concurrently performing data analysis with each set of additional data. We found new data was no longer recurring at participant number 12. We enrolled 2 more participants (stopping criterion) to confirm this. We enrolled 1 more participant with CD to ensure our study sample was more balanced in relation to the distribution of participants with UC and CD.

Data Collection:

We collected demographic and socioeconomic information from participants. Qualitative data was collected using semi-structured interviews completed via videoconference (Zoom, version 6.3.11), with only one participant and one researcher (BO) in each session. Each participant interview was conducted following the interview guide. Interview questions were organized around the COM-B model. The interview questions were developed and refined to elicit capability, opportunity and motivation factors that influence PA participation by participants. Prior to the first interview, the interview guide was reviewed by two patient-partners to ensure comprehensiveness and relevance of the questions. The refined interview guide was pilot-tested with an individual living with a chronic condition prior to commencement of data collection. At each interview, we asked about perspectives on PA participation, their personal experiences with PA engagement, and factors that limited or enhanced their PA participation. The interviews were recorded using Zoom's record feature and transcribed verbatim by a transcription service. To ensure data accuracy, transcripts were verified against original video files by a member of the research team (BO), after which the video files were deleted.

Data Analysis:

Demographic information is presented as counts and percentages. We used NVivo Qualitative Data Analysis software to organized and analyse the transcripts. Using coding reliability thematic analysis with a focus on description,⁴³ we developed the initial codebook using the research objectives. One member of the research team (B.O.) read all the transcripts, analysed the first transcript and refined the coding framework. Another member of the research team (G.R.) reviewed the coded data and coding framework to ensure consistency and accuracy. After review and refinement of the coding framework, analysis of all subsequent transcripts was completed by B.O. and further reviewed by G.R. Discrepancies were resolved through discussion. Our analysis was driven first by the research objectives to generate broad themes. Next, we performed fine-coding to develop significant patterns of shared meanings relevant to our understanding of the study findings. Additional sub-themes were formulated from themes within the data and to provide more concise descriptions.

All themes were then organized under the three key headings of the theoretical framework – capability, opportunity and motivation. This organization facilitated the use of the COM-B model to improve our understanding of the factors that influence PA participation among individuals with quiescent IBD. To ensure trustworthiness and rigour, participants were provided with a summary of study results and asked to verify that their perspectives had been represented. Participants approved the summary, and no further modifications were made. The final results were shared with a patient advisory committee. They confirmed that they could relate with the study results as adults living with IBD themselves (which enhanced the validity of our findings), they recommended using ‘fitness trackers’ instead of using the word ‘gadgets’, and they recommended using visualizations for the results. Their feedback enhanced our understanding and interpretation of study findings.

Results

Between March and July 2023, we interviewed 15 adults with persistent symptoms in quiescent IBD (Table 1). Fatigue was the most frequently experienced persistent symptom, with 13 participants (87%) experiencing it at least sometimes (including ‘often’ and ‘always’); followed by stress (80%), anxiety (73%), depression (53%), abdominal pain (53%) and lastly, joint pain (33%) (Table 2). Interviews lasted between 35 – 60 minutes.

Experiences with PA participation

We used the COM-B model to organize study findings under the headings Capability, Opportunity and Motivation. Based on this organization, we detailed participants’ experiences with performing PA. From their experiences, we explored the factors that influence optimal PA participation (the desired behaviour) among individuals with quiescent IBD (target population). Of note, some themes were identified that influenced more than one of the COM components. We describe each of the themes below with supporting quotes from participants. Quotes are labelled by the participant’s sex, IBD diagnosis and study number.

Figure 1 summarizes the ‘capability’, ‘opportunity’ and ‘motivation’ factors that influenced PA participation among adults with IBD as identified in this study. In this figure, we also highlight that some factors impacted more than one of the COM-B components, e.g., social support impacted both ‘opportunity’ and ‘motivation’ for PA participation and ‘knowledge’ influenced both ‘motivation’ and ‘capability’.

Capability:

We identified five themes that influenced ‘capability’, that is, the extent of someone’s physical and psychological ability or power to engage in PA. They are **persistent symptoms, PA**

engagement prior to IBD diagnosis, maintaining a PA routine, coping strategies and determination:

Persistent symptoms: When discussing their challenges with engaging in PA, the majority of participants highlighted ongoing symptoms despite clinical remission. For example, fatigue, pain (joint pain, abdominal/core pain), and anxiety. All participants reported their specific persistent symptom has often reduced their ability to be as physically active as they would have wanted to be.

“Whether you are doing push ups or running, even walking, you always use your core muscles. And I guess if you have Crohn’s or colitis, you already have more pain there.” Male, CD, #001.

“I guess my fatigue is definitely something that I find is very challenging to overcome. Fatigue is a big one... It’s something that you always have to fight through.” Female, CD, #012.

An important sub-theme we identified related to persistent symptoms was participants’ lack of knowledge on the effect of PA on these symptoms. Some participants reported experiencing anxiety when considering PA participation, due to not knowing whether it could aggravate their ongoing symptoms. A few participants reported that due to not knowing, they chose to abstain from performing PA.

“And it’s a lot, I mean I feel like it’s just the same with like living with IBD in general, like it’s a lot of trial and error in things like, whether it’s food, or whether it’s exercise or anything like that. And like sometimes trial and error gets to be too much. So, sometimes you just have to...take a step back.” Female, CD, #007.

PA engagement prior to IBD diagnosis: When discussing their PA engagement, some participants reported that being physically active prior to getting their IBD diagnosis facilitated their willingness and capability to engage with PA despite ongoing symptoms.

“Well, before I was like sick, I was pretty physical. So, I managed to have like a good starting point for when I was recovering...I didn't find it challenging to get back into exercising. I think. Yeah, I mean it wasn't too hard for me.” Man, CD, #001

From this discussion, we found that those who were less physically active prior to their IBD diagnosis tended to be more cautious with PA engagement due to fear of worsening their symptoms, which consequently reduced their ‘capability’ for PA participation.

“No, I think at the start of everything you need a certain person, like a professional’s advice. I don’t want to do online exercises and the next day I’ll be like, oh, my back hurts. So, I just want to get professional advice at the start and then I’ll make my to-do list.” Female, UC, #009

Maintaining a PA routine: Some participants with an existing PA routine reported finding it less challenging to stay physically active.

“Yeah, I think to get back into it, even just walking, there wasn't a lot of anxiety.” Female, CD, #005.

Interestingly, some other participants reported being unable to establish a routine often due to the unpredictability of IBD.

“I think the problem currently with my routine is like the way I'm recovering, it's just really play by it by ear. Like I'm not dealing with fatigue and pain as the only symptoms of this thing. I also have, like an active wound drainage. So, it's like it's something I need to constantly manage.” Male, UC, #003

“But then it’s also not guaranteed if somebody is really struggling with constant flares then I think that would be really hard to maintain [a routine]. But yeah, if you're just in remission and been able to stay in remission, I think you can definitely maintain a program.” Female, UC, #017

Coping strategies: Most participants reported using coping strategies to improve engagement with PA. The number of coping strategies available to individuals tended to be related to the number of years since IBD diagnosis, i.e., the longer individuals had lived with IBD, the more

coping strategies they had developed. Coping strategies found to influence physical capability included getting optimum nutrition, good sleep, and performing PA during periods of high energy. All these impacted their motivation for PA; which highlights how improvement in one component of the COM impacts other components.

“Also like how well I’m eating is a big factor...if I’m eating well, I feel better. And so then I feel more motivated.” Male, CD, #004

“...like I have to...so like on Monday night, I have to sleep early so that I can wake up early Tuesday because I know I have to go for my activity class and I’ll be more energetic. So that’s the weakest point for me, the energy level one so I’ll get more energy by getting more sleep and I’ll be more active in my class.” Female, UC, #009.

“Yeah. Like, last summer I was still working night shift at the time so when I had bursts of energy at 2 a.m., I’d go to my garage, I’d lock myself in, so I felt safe, and I’d workout in the garage.” Female, CD, #015.

Coping strategies that were found to influence psychological capability included having a positive attitude towards PA and being mindful of the limitations of living with IBD.

“Yeah, but I mean...there’s a lot of mental to the physical part. And something I’ve been kind of coming to terms with is I’m not as capable as a normal person, and that there’s nothing wrong with not reaching 20 (reps) if you achieved 25 (reps) last week. Right? Like there’s ups and downs, that’s kind of how the way the world goes.” Male, UC, #003

Determination: One important theme related to psychological capability was participants’ determination to perform PA despite challenges and barriers. This determination enhanced their ‘capability’ for PA engagement.

“I really don’t try and let my symptoms get in the way of my physical activity. Are some days harder than the other? Yes. Or some days I’m at the gym and some days I have a really bad fatigue and I’m just on the couch. But overall, I think that I do try and lead a very active lifestyle. Because also I think going through the thick of my disease – I think coming out on the other side, I’m a lot more grateful I think – for what my body can do. So, I think that I really try and practice physical activity and I’m just more thankful for it.” Female, CD, #012

“Yeah. Every now and then like I’ll still get like a lot of bloating and there will be like a sharp pain from time to time in my stomach. But it’s really not enough to stop me from being active. And I don’t know, I’m a little bit like strong-willed in that way.” Female, UC, #021

Opportunity:

We identified four themes that influenced ‘opportunity’, which refers to a favourable set of circumstances, for study participants. They were **social support, type of employment, bathroom access, and finances.**

Social support: In their discussion, participants reported that living with IBD as adults requires that they balance living with a chronic condition with work, family, and school responsibilities. This sometimes limited opportunities for PA participation. However, participants reported that family members and friends could be sources of social support for PA engagement, thereby enhancing the opportunity for PA participation. In their discussion, participants highlighted that having this social support also improves their motivation to participate in PA.

“On the days when I didn't want to do it, my mom would push me and vice versa. But yeah, I feel like exercise programs are like, in theory they're great, but if you don't have anybody holding you accountable, there's nothing stopping you from just being like, ‘well, I don't feel like it today’, and the next day you're like, ‘Well, I still don't feel like it’. And then suddenly, it's been 3 weeks, and you haven't done it.” Female, CD, #007.

“My partner, she just got an Apple watch just after Christmas, and it like gamifies physical activity for you. So, I kind of piggybacked on her program. So, whenever she goes and works out I would workout, too, and that whole thing has been really motivating.” Male, CD, #004

“Definitely encouraging me is when other people are doing it, you can kind of do the same thing as them. Just like that P90X work out, you just kind of move along with the routine.” Male, UC, #020

Type of employment: Participants who had jobs that required a lot of physical activity throughout the day reported having opportunities for PA through their employment. They tended

not to be willing to do PA outside of work because it required additional energy in the context of fatigue as a persistent symptom.

“I come home from work, and I’m so tired after work ‘cause I do physical work, I just want to sit down. I don’t want to, you know, go do a workout.” Male, CD, #001

Bathroom Access: The ease of bathroom access in workout spaces was found to affect opportunity for PA participation. All study participants highlighted the value of having access to bathrooms in work-out spaces, such as parks with bathrooms and gyms with private bathroom stalls, as this gave them peace of mind to participate. Lack of bathrooms limited ‘opportunity’ for PA.

“...mentally I have been in a state where I don’t want to exert much physical activity on myself. Because maybe I’m cautious that it will trigger something and if a bathroom is not available to me, I may need to run somewhere. And that has been at the back of my mind. I have realized lately that there’s always – that thought is always running in my mind.” Male, UC, #014

Finances: Most participants reported that the ability to afford equipment, gym memberships or even set up a work-out space within their home enhanced opportunities for PA engagement.

“Yeah. I would say that being able to afford equipment has definitely helped with my activity. As I said, I have an exercise bike, I have free weights, I have bands, I have a squat rack in my garage” Female, CD, #015.

“For me, I’d probably just do like the [workout] videos, I suppose, because, yeah, budget is an issue.” Male, UC, #013

Motivation:

The themes that influenced ‘motivation’, i.e., the complex psychological process that focuses on achieving pre-set goal(s), including both the initiation and maintenance of efforts to achieve the goal(s), were **awareness of the benefits of PA, knowledge of effects of PA on IBD, social supports, and personal goals with a system of tracking progress.**

Awareness of the benefits of PA: From the discussion, some participants believed that performing PA improved their quality of life. Performing PA made them feel happy, improved their self-confidence, and reduced the impact of fatigue. The desire to continue to gain these benefits enhanced their motivation to engage more in PA.

“Like I found that when I’m a little bit more fit, I’m a little bit happier. When I’m a little bit more fit, things just go a little bit easier. My movements are...my bowel movements are a little bit more regular. ...and I think that that’s desirable if you’re kind of living with this condition.” Male, CD, #004

“I think it’s just...you have to do something that makes yourself feel good because I think – when I exercised more or was more physically active, I felt better. So it was just, “Oh. If I get active then I will feel that confidence again.” Female, UC, #011

When discussing their experiences with PA engagement, participants highlighted that the day-to-day experience of living with persistent symptoms of IBD not only impacted the capability to engage in PA, but also reduced their motivation to participate. They highlighted that factors such as bloating, abdominal pain, frequent fatigue, and anxiety, often reduced their motivation for PA participation.

“Yeah, and I would say lack of motivation. But that’s not necessarily due to the IBD. But I mean that also, I guess kind of ties in with the fatigue and, you know, the exhaustion that comes from Crohn’s.” Female, CD, #007

However, despite this, all participants expressed they were aware of the benefits of PA, and ideally wanted to perform more PA. Both males and females reported wanting gains related to better body image and weight loss.

“I saw a picture of myself that my mom took of me. And I was like I hate the way I look and I gotta go do CrossFit. And I just jumped in. It [PA] just kinda made the process faster in terms of getting rid of that whole moon face thing. I knew it was going to go away once I stop taking the drug but it was just really fast [with PA], and it felt great. Male, CD, #001.

“And when you’re on Prednisone, technically your body goes into a fast remission too. So, you’re not really experiencing a lot of the – maybe the same symptoms. Obviously joint pain was huge and the weight gain was huge, but I think at that point – especially with that rapid weight gain – I wish there had been a physical program I could have relied on.” Female, CD, #012

Knowledge: Several participants highlighted a lack of information about PA and IBD, especially early on in their IBD journey. Participants also noted that information available to them about their disease and living with it were often in formats they could not easily understand. This increased their frustration with living with IBD and their anxiety with performing PA. The lack of information not only impacted their motivation to participate but also reduced their capability for participation.

“I think what’s frustrating about getting those materials given to you at first is, I remember being given a book on it but then every chapter or every question you have, the answer’s like, “Well, we don’t know what causes this.” So there’s also no clear answer with IBD for any of the questions you have, so I think I feel like I gave up kind of quickly on searching for those answers.” Female, UC, #017.

Some participants further highlighted that if they could receive information about PA from trustworthy sources like their doctor or from an IBD organization/institution, it would lessen the anxiety around PA participation.

“So having that coordinated information because...and I think that’s what prevents a lot of people when they don’t know what to do or how to do it; having somebody who is like, ‘hey, If you’re like just starting out, or you’ve like lost a bunch of weight or muscle mass due to your condition, and everything hurts, what’s some like really low impact stuff that you can do that you can feel good about and not hurting your body?’ I feel like finding that for myself, that definitely would have helped me out.” Male, CD, #004

“...yeah, if I think I did hear my gastroenterologist say you have to be more physically active and here’s some things you can do, I think that would be a push for sure, a push to do it.” Female, UC, #017.

Social Support: When discussing their experiences, participants often spoke about how living with IBD tends to be isolating. They noted that IBD is rarely talked about and even when it is

talked about, family and friends do not often understand the challenges of living with IBD. The loneliness of living with IBD was found to lessen the motivation to engage in PA. However, as noted earlier, participants highlighted that the availability of a family member or friend who can participate in PA with them, or a support group involving other individuals living with IBD participating in PA, might motivate them to participate. Availability of social support not only provides ‘motivation’ to engage in PA, it also provides ‘opportunity’ for PA engagement.

“And I also found after my latest surgery in 2020, I was messaging with some girls – who are around my age – and I was asking them, “Oh, what do you do when you go to the gym?” And then they would tell me what they would do. And that’s how I got most of the answers, is from a support group.” Female, UC, #011

“And then also, I think if you build community, I think community holds you accountable. So, if you have a group of people you’re working out with consistently – and for four sessions you’re not showing up – I think those people are even going to start looking out for you too.” Female, CD, #012

Personal goals: Some participants found that setting personal PA goals, as well as the availability of a system of tracking progress towards achieving those goals, improved motivation for PA.

“But just tracking things like that sometimes can give you the happy feeling of being like, ‘Oh, I achieved this, and it feels good. So, I’m going to keep trying to go like for like a streak’ or something like that. And you know, do so many days in a row.” Female, CD, #007

“I mean, I enjoy going to the gym, but tracking helps me with reaching my goals faster I would say. So, yeah like if I want to hit certain targets within certain time, then it’s definitely helpful.” Male, UC, #010.

Sex differences in experiences with PA

The thematic analysis revealed only a few sex-related differences in the experiences of PA among study participants. Specifically, **social context of workout spaces and safety concerns.**

Social context of workout spaces: The report of being self-conscious about how they are seen or perceived when in workout spaces, especially gyms, was identified only among some of the female participants.

“But when I’m at the gym, I’m not only focused on the exercise, I am also focused on if my top is lifting, if my bag is showing...so then that makes me not want to spend money on a gym membership to go somewhere where you’re going to get looked at.” Female, UC, #011.

The perception individuals have about their workout spaces may influence their motivation to perform PA in those spaces.

Safety: Females more than males expressed safety concerns when considering options of workout locations. Thus, there might be fewer options available to females when they want to engage in PA compared to males, which may consequently influence levels of engagement between both sexes.

“I like to do my walks in the evenings. But I also find too there's the aspect of safety. Right? And that's the thing. I'm not gonna go if it's getting dark, you know. I feel like I'd be fine, but you never know. And that's something as women, we also have to think about it.” Female, CD, #007.

These themes, social context of workout spaces and safety concerns, may impact the ‘opportunity’ and ‘motivation’ for PA engagement for females but not for males. Thus, women may require different PA engagement options and strategies from men.

Discussion

In this paper, we explored the experiences of PA engagement among adults with quiescent IBD to understand the low PA participation, as noted in previous research among members of this

population. From the experiences of participants, we elicited the factors influencing PA engagement while living with quiescent IBD. We used the COM-B model, which proposes that a desired behaviour (B) is possible when capability (C), opportunity (O) and motivation (M) are present; to organize the study data. From the participants' experiences, we found that presence of persistent symptoms, PA engagement prior to IBD diagnosis, maintaining a PA routine while living with IBD, coping strategies and determination influenced 'capability' for PA participation. Social support, type of employment, bathroom access, and finances influenced 'opportunity'. Having an awareness of the benefits of PA while living with IBD, knowledge of the effects of PA on IBD, social support, and personal goals promoted 'motivation' for PA participation. We also explored sex differences in the experiences and perspectives of study participants. We found that all participants expressed the desire to be more physically active. However, females expressed concerns pertaining to the social context of work out spaces and safety issues.

From participants' experiences with PA engagement, we elicited barriers to and facilitators of PA participation. Barriers included ongoing IBD-related persistent symptoms, low or no PA engagement prior to IBD diagnosis, lack of social support, poor bathroom access, lack of financial support, and lack of knowledge on PA engagement while living with IBD. Factors that can facilitate PA engagement include being physically active prior to IBD diagnosis, development of coping strategies, presence of social support, optimal bathroom access in workout spaces, employment that involves lots of physical activity, availability of relevant knowledge on PA, adhering to a PA routine, and ability to track progress achieved via gadgets and apps.

PA has been reported to be potentially beneficial for individuals with quiescent IBD.^{3, 27,}
⁴⁴ It's been hypothesized that during exercise, interleukin 6 (IL-6) is released from muscles and this exerts an anti-inflammatory effect in those with chronic inflammation, as IL-6 inhibits TNF production and enhance the stimulation of IL-1ra and IL-10.⁴⁵ The full extent of the benefits of PA is yet to be elucidated as research on this subject is quite sparse. In-depth research may be challenging with the lack of evidence-informed PA and exercise guidelines for individuals with IBD. When healthcare providers and individuals with IBD have the necessary guidelines for PA promotion and engagement, research on this subject will hopefully become more homogenous and objective PA data to assess the effects of PA and exercise on IBD can be derived. Our study aimed to bridge this gap by identifying barriers to PA engagement, and highlighting relevant factors to consider to promote PA engagement among individuals with IBD.

The promotion of PA engagement can begin as soon as a diagnosis of IBD is made. Gastroenterologists are in an excellent position to encourage patients to engage in PA, dispel concerns they may have about PA engagement, and make referrals to resources to help patients find their own optimum levels of PA engagement. In a 2019 UK study on PA engagement following stoma surgery, 49% reported not receiving any information or advice about PA.⁴⁶ Similarly, in an Italian cross-sectional study on barriers to PA participation by individuals with quiescent IBD, less than 50% of respondents reported receiving appropriate support from family or gastroenterologists about PA participation. Knowledge on the different types of PA that are beneficial when living with IBD is crucial to promote PA participation.²⁸ Participants in our study emphasized the value of getting knowledge on PA and recommendations for participation from a trusted professional, especially their gastroenterologists as a factor that would enhance both their motivation and capability to participate more in PA. In agreement, participants in the

qualitative study of Wang and colleagues²⁵ emphasized the need for professional guidance for PA engagement. Similarly, a 2022 narrative review concluded that it might be beneficial for physicians to discuss PA programs with their patients especially those dealing with fatigue, depression, anxiety or impaired QoL.⁴⁶

Interestingly, we found that some participants demonstrated determination to participate consistently in PA despite barriers to engagement. Our conceptualization of this theme is that participants demonstrated determination to regain a sense of control over the unpredictability of living with IBD by maintaining a PA routine, i.e., something they could control. Study themes reveal a thread of acceptance and flexibility in living with IBD. This state of acceptance could be leveraged to promote PA engagement via targeted interventions. As highlighted in previous studies,^{47, 48} adults with IBD strive for normalcy in their everyday lives. Being able maintain control over IBD by regularly engaging in PA can help people achieve this normalcy. Targeted interventions to promote PA engagement identified in our study included promotion of PA participation by gastroenterologists and other health care providers by providing knowledge. As well as leveraging family and friends for social supports, developing individualised coping strategies (such as good nutrition, optimum sleep, maximising periods of high energy), setting personal goals and using gadgets and apps to monitor PA engagement.

Study findings revealed that when participants expended effort, time and energy to engage in PA, they found it gratifying to observe the gains, not just in terms of improvement in quality of life, but also the quantification of their progress and achievements. This enhanced their motivation to maintain their PA participation. In the study of Matilla and colleagues,⁴⁹ they used mobile applications in an intervention to promote healthy lifestyle changes in adults with

elevated health risks. They reported that participants valued having a record of their personal progress in real time, observable health outcomes (such as weight loss) and being provided with a personalized exercise plan. Incorporating a system that provides regular feedback may encourage performance and maintenance of PA. With the proliferation of digital health in IBD management,⁵⁰⁻⁵² this might be just the right time for healthcare providers to encourage the use of wearable devices in PA engagement among this group.

A 2024 cross-sectional study investigating the behaviours and barriers to exercise in IBD found engagement was significantly lower among female participants compared to males.²⁸ We found in our study that the social context of workout spaces and safety concerns may impact PA engagement for females but not so much for males. As such, females with quiescent IBD may experience more barriers to PA engagement than their male counterparts. This suggests that females will require additional supports to participate in PA and may require different PA engagement options and strategies (e.g., prioritizing social support, working out in groups, etc.) from males.

Strengths and Limitations:

Previous research has highlighted the low PA participation among adults with quiescent IBD.^{13, 19, 30} But research to improve our understanding of this PA behaviour, as well as facilitators to promote behaviour change is lacking. This study provides highly relevant data to fill this gap. Additionally, this study provides patient perspectives in this area of research, to ensure future research incorporates patients' preferences. Furthermore, using COM-B model to organize our study findings not only enhances the understanding of PA behaviour among those with quiescent IBD; it also provides a comprehensive theoretical framework to underpin the

development of effective, theory-based interventions. A limitation of this study is that only adults between the ages of 20 and 45 years old were included. The perspectives of younger and older participants might provide a more comprehensive understanding of aspects that influence PA behaviour in different age groups. Although we used a systematic approach to determining when to stop recruitment, it is possible that the full range of perspectives and experiences were not included. Our use of videoconferencing software may have limited participation from people who did not have access to the necessary technology. We acknowledge that COM-B coding is a subjective process and there may be different ways of coding the findings. In our analysis, we tailored the COM-B coding to our study objectives, which may not be applicable to other research studies. Despite these limitations, this study provides relevant information for promoting PA behaviour change in the context of living with IBD.

Conclusions:

This study provides more clarity on the factors that influence PA behaviour among adults with quiescent IBD. We have highlighted how the COM-B model can help organize these factors to identify the aspects that influence each component of the COM to promote PA behaviour change. Consistent PA participation may serve as an adjunctive management for the psychological aspects of IBD, which historically receive less attention than physical symptoms.

⁵³ We recommend that clinicians should actively promote PA engagement among their patients with IBD because the patients may need the knowledge on PA and reassurance that participating in PA is safe for them.

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Tables

Table 1: Demographic characteristics

Variable	N (%)
Age	
20 – 24	4 (27%)
25 – 29	8 (53%)
30 – 34	2 (13%)
35 – 40	1 (7%)
IBD Diagnosis	
CD	5 (33%)
UC	10 (67%)
Sex	
Female	8 (53%)
Male	7 (47%)
Gender	
Female	8 (53%)
Male	6 (40%)
I prefer not to answer	1 (7%)
Marital Status	
Single – Never married	7 (47%)
Common-law	4 (27%)
Married	3 (20%)
My relationship status is not listed here	1 (7%)
Highest Level of Education	
Post-Graduate degree	1 (7%)
College/University degree	10 (67%)
High school degree	3 (20%)
Less than high school	1 (7%)
Household income	
Less than \$CAD 25,000 per annum	4 (27%)
\$CAD 25,001 to \$CAD 50,000 per annum	4 (27%)
\$CAD 50,001 to \$CAD 75,000 per annum	2 (13%)
\$CAD 75,001 to \$CAD 100,000 per annum	3 (20%)
More than \$CAD 100,000 per annum	2 (13%)
Smoking status	
Never smoker	12 (80%)
Previous smoker	3 (20%)

Current smoker	0 (0%)
IBD Duration	
1-2 years	5 (33%)
3-5 years	4 (27%)
>5 years	6 (40%)

N= Number of participants CD: Crohn's disease; UC: Ulcerative Colitis; IBD: Inflammatory Bowel Disease

Table 2: Frequency and impact of persistent symptoms

FREQUENCY	Fatigue	Abdominal pain	Joint Pain	Stress	Anxiety	Depression
Never	1	4	5	1	1	5
Seldom	1	3	5	2	3	2
Sometimes	7	5	4	0	1	5
Often	5	3	1	10	9	3
Always	1	0	0	2	1	0
IMPACT	Fatigue	Abdominal pain	Joint pain	Stress	Anxiety	Depression
Not at all	3	6	9	3	4	7
A little	1	4	4	3	2	2
Medium	5	3	1	2	2	2
A lot	6	2	1	4	4	2
Extremely	0	0	0	3	3	2

Figure

Figure 1: COM factors to promote physical activity behaviour change among adults with quiescent IBD



Supplemental Material

Table 1 Supplemental Material: Consolidated criteria for reporting qualitative studies (COREQ): 32-item checklist.³⁹

For: Behaviour Change Considerations to Promote Physical Activity Participation among Individuals with Quiescent Inflammatory Bowel Disease – Barriers and Facilitators

Item No	Guide Questions/Description	Reported on Page # (of the published manuscript)
Domain 1: Research team and reflexivity		
Personal Characteristics		
1. Interviewer/ facilitator	Banke Oketola	Pg. 7
2. Credentials	MSc	Pg. 1
3. Occupation	Clinical Research Coordinator	Not reported.
4. Gender	Female	Not reported.
5. Experience and training	Qualitative research courses at MSc. and PhD levels, 2 previous qualitative research projects; performed data collection, analysis and reporting.	Not reported.
Relationship with participants		
6. Relationship established	No	N/A
7. Participant knowledge of the interviewer	Interviewer's credentials were shared with participants in the informed consent form. Goals for doing the research were shared at the interview.	N/A
8. Interviewer characteristics	Participants were informed that the interviewer is a Physical therapist by training and worked in IBD research for over 6 years. Interest and bias, which is to bring physical therapy into IBD research were also shared with some participants during the interviews.	N/A
Domain 2: study design		
Theoretical framework		
9. Methodological orientation and Theory	Qualitative description	Pg. 5
Participant selection		

Item No	Guide Questions/Description	Reported on Page # (of the published manuscript)
10. Sampling	Purposive sampling	Pg. 6
11. Method of approach	Telephone	Pg. 7
12. Sample size	15	Pg. 10
13. Non-participation Setting	N/A Reasons include scheduling conflicts and not meeting eligibility criteria.	N/A
14. Setting of data collection	Zoom	Pg. 7
15. Presence of nonparticipants	No	N/A
16. Description of sample	Provided.	Pg. 9
Data collection		
17. Interview guide	Semi-structured interview guide was used. It was pilot tested.	Pg. 7
18. Repeat interviews	None	N/A
19. Audio/visual recording	Video-recording	Pg. 7
20. Field notes	None	N/A
21. Duration	35-60 minutes.	Pg. 10
22. Data saturation	Approach to data saturation provided.	Pg. 7
23. Transcripts returned	Summary of findings were provided to participants for review and feedback.	Pg. 9
Domain 3: analysis and findings		
Data analysis		
24. Number of data coders	2	Pg. 8
25. Description of the coding tree	Coding and levels of themes described.	Pg. 8
26. Derivation of themes	Derived in advance	Pg. 8
27. Software	NVivo Qualitative data analysis software by Lumivero	Pg. 8
28. Participant checking	Participants provided feedback on study summary.	Pg. 9
Reporting		

Item No	Guide Questions/Description	Reported on Page # (of the published manuscript)
29. Quotations presented	Participants' quotations were presented to buttress themes and findings. Each quotation was identified by gender, IBD diagnosis and participant ID.	Pg 10 – 19
30. Data and findings consistent	Consistent	Pg 10 – 24
31. Clarity of major themes	Major themes were clearly presented in the results section using headings.	Pg 10 – 19
32. Clarity of minor themes	A description of minor themes and unexpected themes were provided using subheadings.	Pg 10 – 19

Table 2 Supplemental Material: Quotes Table

Experiences with PA participation:

Domain	Themes	Statements
Capability	Persistent symptoms	<i>“Whether you are doing push ups or running, or even walking, you always use your core muscles. And I guess if you have Crohn’s or colitis, you already have more pain there.” Male, CD, #001</i> <i>“I guess my fatigue is definitely something that I find is very challenging to overcome. Fatigue is a big one... It’s something that you always have to fight through.” Female, CD, #012</i> <i>“And it’s a lot, I mean I feel like it’s just the same with like living with IBD in general, like it’s a lot of trial and error in things like, whether it’s food, or whether it’s exercise or anything like that. And like sometimes trial and error gets to be too much. So, sometimes you just have to...take a step back.” Female, CD, #007.</i>
	PA engagement prior to IBD diagnosis	<i>“Well, before I was like sick, I was pretty physical. So, I managed to have like a good starting point for when I was recovering...I didn’t find it challenging to get back into exercising. I think. Yeah, I mean it wasn’t too hard for me.” Man, CD, #001</i>

		<i>"No, I think at the start of everything you need a certain person, like a professional's advice. I don't want to do online exercises and the next day I'll be like, oh, my back hurts. So, I just want to get a professional advice at the start and then I'll make my to-do list." Female, UC, #009</i>
	Maintaining a PA routine	<i>"Yeah, I think to get back into it, even just walking, there wasn't a lot of anxiety." Female, CD, #005.</i> <i>"I think the problem currently with my routine is like the way I'm recovering, it's just really play by it by ear. Like I'm not dealing with fatigue and pain as the only symptoms of this thing. I also have, like an active wound drainage. So, it's like it's something I need to constantly manage." Male, UC, #003</i> <i>"But then it's also not guaranteed if somebody is really struggling with constant flares then I think that would be really hard to maintain [a routine]. But yeah, if you're just in remission and been able to stay in remission, I think you can definitely maintain a program." Female, UC, #017</i>
	Coping strategies	<i>"Also like how well I'm eating is a is a big factor...if I'm eating well, I feel better. And so then I feel more motivated." Male, CD, #004</i> <i>"...like I have to...so like on Monday night, I have to sleep early so that I can wake up early Tuesday because I know I have to go for my activity class and I'll be more energetic. So that's the weakest point for me, the energy level one so I'll get more energy by getting more sleep and I'll be more active in my class." Female, UC, #009.</i> <i>"Yeah. Like, last summer I was still working night shift at the time so when I had bursts of energy at 2 a.m., I'd go to my garage, I'd lock myself in, so I felt safe, and I'd workout in the garage." Female, CD, #015.</i>
	Determination	<i>"I really don't try and let my symptoms get in the way of my physical activity. Are some days harder than the other? Yes. Or some days I'm at the gym and some days I have a really bad fatigue and I'm just on the couch. But overall, I think that I do try and lead a very active lifestyle. Because also I think going through the thick of my disease – I think coming out on the other side, I'm a lot more grateful I think – for what my body can do. So, I think that I really try and practice physical activity and I'm just more thankful for it." Female, CD, #012</i>

		<i>"Yeah. Every now and then like I'll still get like a lot of bloating and there will be like a sharp pain from time to time in my stomach. But it's really not enough to stop me from being active. And I don't know, I'm a little bit like strong-willed in that way." Female, UC, #021</i>
Opportunity	Social Support	<i>"On the days when I didn't want to do it, my mom would push me and vice versa. But yeah, I feel like exercise programs are like, in theory they're great, but if you don't have anybody holding you accountable, there's nothing stopping you from just being like, 'well, I don't feel like it today', and the next day you're like, 'Well, I still don't feel like it'. And then suddenly, it's been 3 weeks, and you haven't done it." Female, CD, #007</i> <i>"My partner, she just got an Apple watch just after Christmas, and it like gamifies physical activity for you. So, I kind of piggybacked on her program. So, whenever she goes and works out I would workout, too, and that whole thing has been really motivating." Male, CD, #004</i> <i>"Definitely encouraging me is when other people are doing it, you can kind of do the same thing as them. Just like that P90X work out, you just kind of move along with the routine." Male, UC, #020</i>
	Type of employment	<i>"I come home from work, and I'm so tired after work 'cause I do physical work, I just want to sit down. I don't want to, you know, go do a workout." Male, CD, #001</i>
	Bathroom access	<i>"...mentally I have been in a state where I don't want to exert much physical activity on myself. Because maybe I'm cautious that it will trigger something and if a bathroom is not available to me, I may need to run somewhere. And that has been at the back of my mind. I have realized lately that there's always – that thought is always running in my mind." Male, UC, #014</i>
	Finances	<i>"Yeah. I would say that being able to afford equipment has definitely helped with my activity. As I said, I have an exercise bike, I have free weights, I have bands, I have a squat rack in my garage" Female, CD, #015.</i> <i>"For me, I'd probably just do like the [workout] videos, I suppose, because, yeah, budget is an issue." Male, UC, #013</i>
Motivation	Awareness of the benefits of PA	<i>"Yeah, and I would say lack of motivation. But that's not necessarily due to the IBD. But I mean that also, I guess kind of ties in with the fatigue and, you know, the exhaustion that comes from Crohn's." Female, CD, #007</i>

		<i>“I saw a picture of myself that my mom took of me. And I was like I hate the way I look and I gotta go do CrossFit. And I just jumped in. It [PA] just kinda made the process faster in terms of getting rid of that whole moon face thing. I knew it was going to go away once I stop taking the drug but it was just really fast [with PA], and it felt great. Male, CD, #001.</i> <i>“And when you’re on Prednisone, technically your body goes into a fast remission too. So, you’re not really experiencing a lot of the – maybe the same symptoms. Obviously joint pain was huge and the weight gain was huge, but I think at that point – especially with that rapid weight gain – I wish there had been a physical program I could have relied on.” Female, CD, #012</i> <i>“Like I found that when I’m a little bit more fit, I’m a little bit happier. When I’m a little bit more fit, things just go a little bit easier. My movements are...my bowel movements are a little bit more regular. ...and I think that that’s desirable if you’re kind of living with this condition.” Male, CD, #004</i> <i>“I think it’s just...you have to do something that makes yourself feel good because I think – when I exercised more or was more physically active, I felt better. So it was just, “Oh. If I get active then I will feel that confidence again.” Female, UC, #011</i>
	Knowledge of effects of PA on IBD	<i>“I think what’s frustrating about getting those materials given to you at first is, I remember being given a book on it but then every chapter or every question you have, the answer’s like, “Well, we don’t know what causes this.” So there’s also no clear answer with IBD for any of the questions you have, so I think I feel like I gave up kind of quickly on searching for those answers.” Female, UC, #017.</i> <i>“So having that coordinated information because...and I think that’s what prevents a lot of people when they don’t know what to do or how to do it; having somebody who is like, ‘hey, If you’re like just starting out, or you’ve like lost a bunch of weight or muscle mass due to your condition, and everything hurts, what’s some like really low impact stuff that you can do that you can feel good about and not hurting your body?’ I feel like finding that</i>

		<i>for myself, that definitely would have helped me out.”</i> Male, CD, #004 <i>“...yeah, if I think I did hear my gastroenterologist say you have to be more physically active and here’s some things you can do, I think that would be a push for sure, a push to do it.”</i> Female, UC, #017.
	Social support	<i>“And I also found after my latest surgery in 2020, I was messaging with some girls – who are around my same age – and I was asking them, “Oh, what do you do when you go to the gym?” And then they would tell me what they would do. And that’s how I got most of the answers, is from a support group.”</i> Female, UC, #011 <i>“And then also, I think if you build community, I think community holds you accountable. So, if you have a group of people you’re working out with consistently – and for four sessions you’re not showing up – I think those people are even going to start looking out for you too.”</i> Female, CD, #012
	Personal goals with a system of tracking progress.	<i>“But just tracking things like that sometimes can give you the happy feeling of being like, ‘Oh, I achieved this, and it feels good. So I’m going to keep trying to go like for like a streak’ or something like that. And you know, do so many days in a row.”</i> Female, CD, #007 <i>“I mean, I enjoy going to the gym, but tracking helps me with reaching my goals faster I would say. So, yeah like if I want to hit certain targets within certain time, then it’s definitely helpful.”</i> Male, UC, #010.

Sex Differences:

Themes	Statements
Social context of workout spaces	<i>“But when I’m at the gym, I’m not only focused on the exercise, I am also focused on if my top is lifting, if my bag is showing...so then that makes me not want to spend money on a gym membership to go somewhere where you’re going to get looked at.”</i> Female, UC, #011.
Safety concerns	<i>“I like to do my walks in the evenings. But I also find too there's the aspect of safety. Right? And that's the thing. I'm not gonna go if it's getting dark, you know. I feel like I'd be fine, but you never know. And that's something as women, we also have to think about it.”</i> Female, CD, #007.

Chapter 4

Study 2 – Second Paper: Perspectives of individuals with inflammatory bowel diseases (IBD) on the design and development of an IBD-specific physical activity program.

Publication Status:

This manuscript has not yet been submitted for publication.

Citation:

N/A

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Abstract:

Background: Physical activity (PA) has been recommended for adults with chronic conditions such as Inflammatory Bowel Disease (IBD) because PA may reduce some persistent symptoms and improve quality of life. Existing research shows that adults with IBD do not engage in recommended levels of PA. This might be due to the lack of PA programs unique to people with IBD.

Aim: To obtain the perspectives of adults with IBD to inform the design and delivery of an IBD-specific PA program.

Methods: In this qualitative description study, we purposively enrolled and interviewed adults with quiescent or mildly active Crohn's disease (CD) and Ulcerative colitis (UC) in Manitoba. Participants described their preferences for the design and delivery of a PA program via semi-structured interviews which were recorded and transcribed. We organized our data and performed thematic analysis using NVivo Qualitative data analysis software. Study findings were structured using the Capability-Opportunity-Motivation and Behaviour (COM-B) model.

Results: Fifteen participants were enrolled, (20 – 37 years of age; 8 women; 10 with UC; 0 current smoker). Using the COM-B model, we categorized data into three main themes participants indicated are crucial to the design of an IBD-specific PA program. To increase 'capability' for PA, participants recommended programs incorporate personalization, knowledge on PA and IBD, and supervision. They highlighted that delivering the program using cell phone apps can promote 'opportunity'. Participants reported that incorporating social support, methods to track PA engagement, and minimizing program barriers may increase 'motivation' to be active.

Conclusion: The components elicited in this study should be incorporated in the design of IBD-specific PA programs. Availability of such programs can potentially increase PA engagement among adults with IBD, leading to better health outcomes.

Key words: Quiescent IBD, IBD physical activity, Intervention design, Behaviour Change, COM-B Model.

Introduction

Inflammatory bowel disease (IBD) refers to chronic inflammation of the gastrointestinal tract and consists of two major subtypes: Crohn's disease (CD) and ulcerative colitis (UC).¹ Both CD and UC are characterized by periods of active inflammation of the digestive tract and remission of this inflammation.² IBD is said to be in quiescent state when the disease is in remission or inactive. Symptom burden in IBD is greater during periods of active intestinal inflammation compared to periods of quiescence.^{3,4} However, some individuals with IBD continue to have symptoms even in the absence of intestinal inflammation.⁵ In a 2023 report, the prevalence of IBD in Canada was estimated to be 825 per 100,000, suggesting that over 320,000 Canadians were living with IBD.⁶ IBD is a chronic, incurable disease and may result in notable long-term health burdens over an individual's lifetime.^{5,7} With the increasing prevalence of IBD, it has been suggested that future research should include a focus on alleviating symptom burden in the quiescent disease phase.^{8,9}

Physical activity (PA) and its subset exercise have been used to complement medical management in a variety of chronic diseases.^{10,11} The World Health Organization (WHO) defines PA as “any bodily movement produced by skeletal muscles that requires energy expenditure...including movement during leisure time, for transport to and from places or as part

of a person's work".¹² Exercise, as defined by the WHO, is a "subcategory of physical activity that is planned, structured, repetitive, and purposeful in the sense that the improvement or maintenance of one or more components of physical fitness is the objective" (pp. vi). We use 'PA' in this paper to encompass all forms of activity, including exercise. The WHO recommends adults with chronic conditions engage in regular PA to improve quality of life (QoL), reduce the rate of disease progression and contribute to healthy aging.¹³ To clarify how to optimally engage in PA, the Canadian 24-hour Movement guidelines¹⁴ recommend that adults 18-64 years of age perform at least 150 minutes of moderate to vigorous physical activities each week.

PA has been identified as one of the adjunctive therapies that may be beneficial in the management of IBD.^{1, 15} Increasing evidence suggests that regular aerobic exercise is beneficial to the gut microbiota, as it increases microbial diversity, and increases the health-beneficial gut bacteria populations.¹⁶⁻¹⁸ The gut microbiome, similar to the skeletal muscle, is plastic and can respond to environmental factors like PA/exercise, altering its composition.¹⁹ This can stimulate beneficial adaptations and improve long-term resilience of the gut barrier, reduce transit time in the large intestine, accelerate movement of gas through the GI tract, increase mechanical forces in the abdomen which may potentially influence gut motility, and promote the maintenance of an anti-inflammatory state.^{16, 17} As such, increasing PA participation among those living with IBD may reduce some persistent IBD symptoms and improve QoL. However, recommended levels of PA are not achieved by most individuals with IBD and are consequently not able to maximise the potential benefits of PA.^{20, 21}

A 2025 cross-sectional study using Manitoba IBD Research Registry data found only 25.5% of respondents self-reported being highly active; others were either moderately active (32%) or inactive (42.5%).²² Another study exploring IBD patient experiences with PA

engagement highlighted the benefits of PA for IBD, as well as the challenges with performing PA.²³ They reported pain, fatigue, and exercise-induced bowel movements as barriers to PA engagement. Similarly, a 2023 study²⁴ exploring the perception of adults with CD who just completed a combined impact and resistance training program, revealed themes including receiving IBD diagnoses, lack of knowledge and confidence to perform PA, and unavailability of exercise advice, as barriers to participation. Designing PA programs that limit barriers specific to IBD may promote PA engagement.

Research suggests that to design an intervention aimed at increasing PA engagement, it is crucial to keep the complexity of PA behaviour change in mind,²⁵ especially for individuals with IBD who sometimes continue to experience persistent symptoms such as fatigue, abdominal pain, joint pain, and fecal urgency.^{20, 26} Eliciting the perspectives of individuals with IBD and their preferences for PA participation via qualitative research, can provide relevant information necessary to understand PA engagement behaviour among individuals with IBD; with the goal of designing PA programs that are suitable, acceptable, and adaptable for this population. This study is part of an overarching project focused on increasing PA engagement among adults with quiescent IBD. The purpose of this current study was to explore patient perspectives on PA engagement, and their perspectives on the design and delivery of PA programs for adults with quiescent IBD.

The objectives of the study were to:

1. Explore user perspectives on key design components of an IBD-specific PA behaviour change intervention.
2. Identify PA program outcomes important to adults with IBD.

Methods

Study Design: A qualitative description design^{27, 28} was utilized to explore patients' perspectives on the design of PA programs, factors that promote engagement, and barriers to participation and adherence.

Theoretical framework:

The theoretical understanding of a behaviour change is crucial in order to maximise the potential efficacy of an intervention.²⁹ According to a 2021 systematic review,³⁰ no one theory appears to be superior to others with respect to correlates of PA/exercise. We used the Capability, Opportunity, Motivation and Behaviour (COM-B) model of behaviour change in this study as it provides an overarching model that encapsulates factors that influence behaviour change.³¹⁻³³

The COM-B model developed by Michie and colleagues proposes that behaviour (B) will occur when three important conditions interact - capability (C) that make it possible to perform the behaviour, opportunity (O) for participation and engagement, and motivation (M) to follow through.³⁴ As clarified by the developers of this model, for an individual to carry out a specific behaviour (B) at any given moment, they must have the necessary physical and psychological capability (C), access to both social and physical opportunity (O), and sufficient motivation (M), both automatic and reflective, to act.²⁵

Philosophical assumptions:

We incorporated rigour by utilizing the constructivist paradigm and the participant lens.^{35, 36} The constructivist paradigm suggests that realities emerge from the interaction between humans and the external world, implying that knowledge should be generated through multiple perspectives.

³⁷ IBD affects individuals with IBD differently. Additionally, various socioeconomic factors

shape how the disease affects individuals, and influence the perspectives they have of the disease and of PA. This necessitates approaching knowledge generation on this subject from diverse realities. The participant lens focuses on checking that the participants' realities are accurately represented in the final account.³⁶ By using this lens, we centre the participants in the analytical process, such as by using member checking. Even though participant lens was utilized, we incorporated reflexivity as researchers to remain engaged and conscious of the ways our biases may influence the analysis.³⁸

This study was approved by the University of Manitoba Health Research Ethics Board. We performed our reporting according to the consolidated criteria for reporting qualitative research (COREQ).³⁹

Study population: We purposively recruited Manitobans between the ages of 20 and 45 years, with a clinical diagnosis of CD or UC. We applied the age limits to focus on the peak age groups of IBD onset, especially as adults of different age groups may experience IBD and PA engagement differently. Participants were eligible if they had quiescent or mildly active IBD and continued to have at least one of the following persistent symptoms with quiescent IBD - abdominal pain, joint pain, fatigue, stress, anxiety and depression. Individuals with moderate or severe disease on the Harvey Bradshaw Index (HBI) for CD and Partial Mayo Score (PMS) for UC^{40, 41} were excluded. Participants were required to have access to supports for videoconferencing for the interviews to eliminate travel costs to the study site.

Participant recruitment: Using maximum variation purposive sampling⁴² based on age, sex and IBD diagnosis, we enrolled eligible participants from gastroenterology clinics, Crohn's and Colitis Canada (CCC) – Manitoba Chapter, and through previous researcher contacts with

patients who had consented to be contacted about future research. All participants provided signed informed consent. We approached data saturation using the strategy described by Francis and colleagues.⁴³ Of the 22 potential participants approached by the research team, seven were either ineligible or had scheduling conflicts. We purposively selected five male and five female participants for our initial analysis sample. Data analysis was conducted to assess whether new insights and shared meanings were continuing to emerge. Once we confirmed that novel information was still being generated, we proceeded with participant enrolment in increments of two, analyzing each new set of data as it was collected. By participant 12 no new themes were identified. To confirm this, we enrolled two additional participants as stopping criteria. One more participant with CD was included to improve the balance between participants with UC and CD in the study sample. The true point of data saturation can be hard to determine; as it is possible that a new participant can bring another perspective that had not been previously recorded in the dataset, thus it may be impossible to achieve absolute saturation.⁴⁴ As such, we are not able to guarantee data saturation was achieved. Nevertheless, our strategy enabled us to approach the decision on when to stop data collection systematically.

Data collection: We gathered demographic and socioeconomic data from participants.

Qualitative data were collected through semi-structured interviews conducted via videoconference (Zoom, version 6.3.11), with one participant and one researcher (B.O.) present during each session. Interviews followed a semi-structured guide (Appendix I), which was reviewed in advance by two patient-partners to ensure the relevance and completeness of the questions. The finalized guide was pilot-tested with an individual living with a chronic condition before formal data collection began. During the interviews, participants were asked about their views on PA engagement, and their ideas about how a PA program should be designed and

delivered. Interviews were recorded using Zoom's recording feature and transcribed verbatim. To ensure accuracy, transcripts were cross-checked against the original video recordings.

Data analysis: Demographic information is presented as counts and percentages. We used NVivo Qualitative Data Analysis software (NVivo 14, released 2023) for data organization. We utilized coding reliability thematic analysis with a focus on description.⁴⁵ The coding framework was initially developed using the research objectives. One team member (B.O.) read all transcripts, conducted the initial analysis of the first transcript, and refined the preliminary coding framework. A second team member (G.R.) reviewed the coded data and the framework to ensure consistency and accuracy. Following this review and further refinement, B.O. analyzed the remaining transcripts, with G.R. providing an additional layer of review. Discrepancies were resolved through discussion. The analysis was initially guided by the research objectives to identify broad themes. This was followed by fine-coding to uncover patterns and shared meanings relevant to the study's objectives. Additional sub-themes were developed from emerging patterns in the data to capture more specific insights into patient perspectives on PA program design.

Lastly, we categorized all identified themes according to the three components of the theoretical framework—capability, opportunity, and motivation. This categorization allowed us to use the COM-B model to organize the components relevant for the design of an intervention with a higher chance of success. To ensure trustworthiness and rigour, participants were given a summary of the study findings and asked to confirm that their views were accurately reflected. All participants approved the summary, and no changes were required. The final results were also shared with a patient advisory committee, whose feedback further informed and enriched the interpretation of our findings.

Results

Participants: We interviewed 15 participants (female = 8, 53%) with quiescent IBD. Their ages ranged between 20 – 37 years, and seven (47%) were single or never married. Most of the participants had UC (n = 10, 67%) and most had a college/university degree (n = 10, 67%). Household income varied; 4 participants (27%) earned less than \$25,000 per annum, 4 (27%) earned \$25,001 to \$50,000 per annum, and 5 (33%) earned more than \$75,000 per annum. None of the study participants was a current smoker, three (20%) were previous smokers. During the interviews, many of the participants reported being physically active at the time of data collection. The others had interest in being physically active, but experienced barriers to engagement preventing them from being as physically active as they would have wanted. Fatigue was the most common persistent symptom reported by participants, with 13 participants (87%) experiencing fatigue sometimes, often or always. Next was stress (80%), then anxiety (73%), depression (53%), and abdominal pain (53%), with joint pain being the least frequently experienced symptom (33%). Interview duration ranged between 35 – 60 minutes.

Research objective #1: To explore patient perspectives on key design components of an IBD-specific PA behaviour change intervention.

We elicited participant perspectives relevant for the design of an IBD-specific PA program and organized the study data using the COM-B model. We sought themes that promoted capability, opportunity and motivation for PA behaviour change. All themes are described below with supporting quotes from participants. For each quote, we have included the participant's sex, IBD diagnosis and study participant identification code.

Capability: We identified three themes that influenced 'capability', which refers to the extent of

someone's physical and psychological ability or power to engage in PA.⁴⁶ The themes are **personalized PA program, knowledge regarding specific PA to perform while living with IBD, and availability of supervision.**

- a. Personalized PA program: In the participants' discussion on living with IBD, they highlighted that IBD affects people differently which makes the experience of living with IBD individualized. As such, their engagement with PA will vary depending on individual experiences of living with IBD, as well as by socioeconomic factors and environment. Thus, having a PA program that is personalized or tailored to their unique personal characteristics could enhance their capability for PA engagement.

"One thing that might help is, like, being able to set up an online appointment with a personal trainer or someone to say, like, hey, I'm getting into exercises. Like, these are my goals. And then, like, just having a resource, say people aren't used to lifting weights and they want to get a little bit more muscular or they want to do that kind of activity. Just having someone who's able to say don't do it that way; you're going to hurt yourself. Here are some resources that you can look at. Might be helpful." Female, CD, #015.

Another participant suggested providing a system where people can personalize the program by themselves without a professional's involvement. That is, provide a variety of exercises and activities each person can choose from (not just provide a set of 5-7 activities they must perform, or a walking program or a yoga program, etc.), perform them wherever they want (could be at home, gym or outdoors), and whenever they want (morning, noon or night depending on factors like energy levels, time, weather, etc.).

"...sort of flow chart type idea [the program], you know, where people can navigate it for themselves if need be. But you know, the more eyes-on type approach for other people." Male, UC, #013.

Participants also noted that an individualized program should not just be tailored to each individual but be adaptable because IBD affects individuals differently from day to day.

Participants emphasized that due to the nature of the disease, each individual will benefit from

having the flexibility to review their symptoms and energy level from day to day, and then decide what they can participate in. Thus, the availability of a PA program that offers a level of flexibility will not only enhance their ‘capability’ to be physically active but can potentially improve their ‘motivation’ for PA engagement.

“...like, say try to be active X number of days a week and then make recommendations of activities if you’re feeling great or activities if you’re not feeling great and then kind of go from there. That way you’re not completely sedentary....Like, OK, take stock of how you’re feeling that day and if you’re not feeling great, go for a walk. If you’re feeling like you want to do exercise, then exercise and then go from there. Don’t try to, like, jump in the deep end” Female, CD, #015

- b. Knowledge on specific PA to perform while living with IBD: During their interviews, participants reported that there was a lack of information about PA and IBD.

“Nothing (information) like explicitly for IBD besides things I’ve heard like through my work, or like through volunteering and stuff like that. And I know, like Crohn’s and Colitis Canada, we’ve done like yoga classes and things like that for people living with IBD. But yeah, nothing like explicitly IBD and physical activity related.” Female, CD, #007.

One participant talked about how they received minimal information about PA from professionals.

“And they were just, “Oh yes. Just be active as much as you can.” And that was it, and I was like, “That was not very helpful.” Female, UC, #011

As such, not knowing the exercises to perform while living with IBD made some participants abstain from PA participation, especially in the early stages after diagnosis.

The majority of participants reported that having access to information on specific activities and exercises to perform (or avoid) while living with IBD, in formats they can easily use, could improve their ‘capability’ to participate in PA.

“And I know I mentioned this to you before. I think in our conversations, but even just bending over and having that compression on the abdomen would trigger a bowel movement, and I’d have to go to the washroom. So, I’m like, how do I go to the gym and pick up anything off the floor? Or going for a walk and tying my shoe, right? So, I just avoided that for a long time.” Female, CD, #005

- c. Availability of supervision: Study participants had differing preferences for having a professional provide supervision and guidance on their participation and progression through a PA program. A supervised PA program was found to be more of a priority for participants in the early periods of living with IBD, shortly after surgery or shortly after having a flare, to guide them on what to do and how to do it.

“Yeah, just some guidance about how to work out more efficiently, and to do it a little more smarter and after like 3 months or so they want you to start getting into the habit of working out and building up your strength again. I was working out a good few weeks, and it really hurt me so. So, yeah, I think supervised would be way to go.” Male, UC, #003.

“I think I would get annoyed with supervised physical activity. I don’t really like being told what to do.” Female, CD, #015

Opportunity:

The availability of **mobile phone applications (apps) to deliver PA** was identified by some participants as potentially providing ‘opportunity’, that is, a favourable set of circumstances, for PA.⁴⁷

Using phone apps to deliver PA: We asked participants about their thoughts on how to best deliver PA programs, whether through websites, cell phone apps, YouTube videos, in-person classes, etc. Most participants reported that using cell phone apps to deliver PA programs could make it more convenient to participate which would consequently reduce the burden of participation. This may enhance ‘opportunity’ for PA engagement. Participants reported that apps can provide easy access to activities to perform, reminders to engage, and potentially keep

track of what they are performing.

“...but even if was an app or something, if you had an app with ideas of what to do. Or if you could make a program in an app and that way you could get notifications from the app to do whatever it is, whatever workout program or something you're doing.” Female, UC, #017.

“I mean like some sort of like app that you can do. I think, even having access into a community, I think that would kinda help.” Male, CD, #004.

“I think so, because I’m always on my phone so...Most people have Smartphones, so it’s like you can have something on the app and then you can also have information on the app and you can have how-tos on the app. So it can be a place where you can just go to if you have a question, or you want to keep track of your progress.” Female, UC, #011.

“But I feel like sometimes people just need those reminders (from apps). So yeah, I think it just kind of depends when it is in front of you. But I think reminders can be good, and I mean, it helps with accountability. And that's another thing too.” Female, CD, #007.

Motivation:

Thematic analysis revealed three themes that influenced ‘motivation’, i.e., the complex psychological process that focuses on achieving pre-set goal(s), including both the initiation and maintenance of efforts to achieve the goal(s).⁴⁸ They are **social support**, **methods to track PA engagement**, and a **program that minimizes burdens and barriers**.

- a) Social Support: Some study participants discussed the benefits of having social support and reported that a PA program that offers engagement within a group setting can provide social support to motivate them to engage in PA. Some participants reported having a preference for performing PA with a group in hopes of having their social needs met while concurrently gaining the benefits of PA.

“I think it would just motivate me like knowing that other people with my condition are able to do it (physical activity) and seeing their strength and their drive to do it. I think that that would empower me and I’d want to be motivated and continue doing that as well.” Female, UC, #021

“I think again it kind of ties into the social factors. I feel I was really motivated to workout when I had somebody I was carpooling to the gym with every morning. And that I had people at the gym, we were doing the same workouts in the morning and knew the instructors and those kind of things.” Female, UC, #017

“Definitely encouraging for me is when other people are doing it, you can kind of do the same thing as them. Just like that XXX work out, you just kind of move along with the routine.” Male, UC, #020

On the other hand, a few participants expressed preference for performing PA by themselves.

“Some people might need that pressure to keep going, other people might actually be deterred by it. So yeah, adaptability would probably need to be the focus.” Male, UC, #013.

“For me myself, I think I like doing it individually. Just because then I can do it whenever I like...but then also having that group activity...they kind of like bleed into each other right? Then you take that a little bit further and do it specifically for what your needs are in like your own home or your own private gym, or something like that.” Male, CD, #004.

- b) Methods to track PA engagement: When discussing their experiences with PA engagement, many participants highlighted the value of monitoring and quantifying their progress when they participate in PA. They highlighted that this tracking could be done on their smartphones, on paper or even on a calendar. Access to this information can motivate them to continue to engage in PA.

“But just tracking things like that sometimes can give you the happy feeling of being like, ‘Oh, I achieved this, and it feels good. So I’m going to keep trying to go for like a streak’ or something like that. And you know, do so many days in a row.” Female, CD, #007

“I mean, I enjoy going to the gym, but tracking helps me with reaching my goals faster I would say. So, yeah like if I want to hit certain targets within certain time, then it’s definitely helpful.” Male, UC, #010.

- c) A program that minimizes burdens and barriers: The majority of participants highlighted that PA engagement tended to require significant amounts of mental and physical energy, in addition to the energy requirement of living with IBD. They emphasized that a PA

program that offers flexibility with participation and is easy to engage with can minimize the burden of engagement and barriers to participation. The reduced burdens and barriers may enhance motivation to participate.

“It’s just a whole thing (preparing for a work-out session). I have to get dressed. I have to figure out what I’m going to wear. I have to make sure my legs are shaved. I have to go there. I have to figure out what I’m going to do there. Then I have to either decide if I’m going to stink on the way home or I had to shower in the showers over there. And then I have to come home and it’s just...yeah no.” Female, CD, #015.

“Yeah, I mean, it depends honestly. Because if I had a FitBit, then it would be like, okay, I’m doing my workout, and then, as soon as I shut my work out off, it sends that information into this group. And I can see what everybody else is doing. I think that would be like frictionless, you know, frictionless app stuff. I think that that would definitely help.” Male, CD, #004.

Research objective #2: To identify PA program outcomes important to adults with IBD.

We asked study participants how they might benefit from participating in an IBD-specific PA program. Overall, study participants identified four outcomes that were important to them:

1. Improvement of symptoms and quality of life.

“Just I know I feel better when I’m more active and I know that being more active can reduce the risk of not only some Crohn’s-related comorbidities but also, like, just general health stuff. Because, like, Crohn’s is only one brick in the pile. Like, you add diabetes and heart disease and arthritis and all that stuff to it.” Female, CD, 015

“Living a better life with this. Yeah.” Male, UC, #014

2. Gaining access to a community of individuals living with IBD where they can connect, as well as learn from the experiences of others.

“But, in terms of the community aspect, probably maybe even friendships. I mean there’s also no – there’s no cure for Crohn’s disease or ulcerative colitis, so it’s something that I’m going to live with for the rest of my life. So, I think building a

community of people that you can lean on in your journey – 10 to 15 years from now – is also really important because there is no cure.” Female, CD, #012

“I think it would be connection with people, and also confidence in physical activity.” Female, UC, #011

3. Improvement in body image.

“I think if you exercise, then you feel better and then you get confident, and your body image improves.” Female, UC, #011

“In terms of losing weight, that’d be my main goal. And then the more I think about it...becoming less systematic or just gaining confidence.” Male, UC, #020.

4. Gaining a sense of control over IBD: An important factor that contributes to anxiety for some participants is the unpredictability of living with IBD and never knowing how bad persistent symptoms will be from day to day. In their discussion, participants highlighted that PA engagement is an aspect of their lives they can control to some extent. Participating in PA and achieving gains such as improvements in mental health, improved body image and increased confidence, were considered by participants as ways to help achieve control over the unpredictability of living with IBD. Having this sense of control can potentially reduce the anxiety and/or stress about the disease, motivating them to maintain PA participation.

“I mean, obviously I think improvement in symptoms would be great, but I don't know if that would necessarily be the case. But that being said, if it helps improve your mental health, then that could improve your symptoms. But I think also, maybe just also that kind of an ownership and just positive reinforcement for yourself and for your health too. Also, I think that it speaks to accomplishment, even if it's something small. I think those are like big things.” Female, CD, #007

Discussion

Physical activity is increasingly recognized as a meaningful adjunct therapy in IBD;^{23,24} and PA participation may also reduce inflammation and positively modulate gut microbiota in individuals with IBD.^{16,17} Many adults struggle to engage in regular activity due to disease-specific barriers. To support effective and sustainable PA participation, it is important to understand patient preferences for how an IBD-specific PA program should be structured. In this qualitative description study, we explored patients' preferences for the design of an IBD-specific PA program to increase PA engagement among adults with IBD. We organized the study findings using the COM-B model, which proposes that a desired behaviour (B) is possible when capability (C), opportunity (O) and motivation (M) are present. We found that capability for PA participation may be promoted by developing a PA program that incorporates personalization of PA and exercises, regular provision of knowledge about PA participation while living with IBD, and availability of supervision when preferred. This program could be delivered using mobile phone apps to enhance opportunities for users. To promote motivation, this program should offer the possibility of social support, ability to track PA performed, and flexibility in participation to limit burdens and barriers. In addition, we explored benefits identified as being important to users participating in an IBD-specific PA program. Thematic analysis identified a) alleviation of symptoms and improvement in QoL, b) access to a community of others living with IBD, c) improvement in body image, and d) gaining a sense of control over the disease.

The unpredictable cyclic nature of IBD may be an implicating factor in patients' abilities to participate in PA.⁴⁹ An important finding in our study is the need to have a PA program that is personalised, not just to the reality of living with IBD, but also to the day-to-day unpredictability of IBD symptoms. Ability to tailor the activity, including intensity, duration and frequency from

day to day, to their specific persistent symptom(s) may make a PA program attractive and realistic for adults with IBD. For example, those experiencing persistent knee joint pain can avoid high impact exercises such as jumping jacks and focus instead on low impact exercises such as quadriceps isometric setting exercises.

Our findings suggested that some participants preferred group sessions while others preferred to participate alone. Studies investigating PA engagement in a group highlight benefits such as enjoyment, adherence to PA participation and reduction in sense of isolation; suggesting that social support contributes to motivation for participation.⁵⁰⁻⁵² However, having the ability to choose when to participate individually or with a group can be empowering for individuals with IBD. Even though participating in a group offers benefits, participating alone can offer easy access to bathrooms and ability to participate at one's own pace. Further, participants who were in the early stages of their IBD journey expressed a preference for supervision to gain knowledge on what exercises to perform and how to perform them; while those living with IBD for much longer preferred no supervision. As such, designing a PA program that can be performed strictly with a group or strictly with supervision might be inclusive or exclusive of some individuals. This reinforces the need for a versatile program that offers high levels of personalization.

The majority of IBD patients believe they are able to participate in PA and exercise, but the lack of recommendations and clear guidelines has limited their participation.²¹ In agreement, the themes identified in this study reinforce the value of having knowledge on specific PA and exercises that can be performed by individuals living with IBD; those that will not worsen IBD-related symptoms and how performing these activities will impact IBD and overall health. Thus, it would be beneficial to have recommendations for activities and exercises for those recovering from a flare and prolonged bedrest (such as early mobilization and frequent short walks), battling

weight gain from prednisone use (e.g., aerobic exercises), activities to improve bone mineral density (e.g., resistance exercises), alternative activities for those with symptoms like abdominal pain (e.g. wall sits and planks instead of exercises like crunches) and joint pain, and activities to improve persistent symptoms such as anxiety, depression, fatigue and joint pain. Access to this information can increase confidence for these individuals to perform PA.

An important finding in this study is participants' need for a program that offers flexibility with engagement, reduces barriers to PA participation and promotes ease of engagement. Participating in, and adhering to a PA program in the general population comes with barriers and challenges.⁵³ Several cross-sectional studies have shown that adults living with quiescent IBD may encounter additional barriers related to their disease course.^{21, 23, 54, 55} Chae and colleagues²¹ suggested that when designing a PA program, identifying and mitigating barriers to PA engagement are important to improve participation. A program that offers flexibility with engagement, such as one that can be performed at home when the individual experiencing persistent fatigue feels more energetic, can promote ease of engagement, rather than a program that must be completed at a specific time on a specific day. Additionally, a PA program delivered via a cell phone app, with a chat feature, can be performed at home; and this can remove barriers such as the cost of gym membership and transportation to the gym, while still providing opportunity for social support to users. This flexibility can increase capability and motivation for PA participation.

In the study, we explored how adults with IBD would benefit by participating in an IBD-specific PA program. Chronic conditions such as IBD impact multiple dimensions of life, including overall QoL and social participation beyond indices of inflammation.⁵⁶ As such, eliciting patient-reported outcomes are important considerations. Participants of this study

highlighted alleviation of persistent IBD symptoms, improvement of QoL, access to a community of others living with IBD, improved body image and gaining control over the disease. Research has shown that PA improves mood, physical fitness, and contributes to increases in bone mineral density, all of which promote improved QoL in IBD.²⁰ The changes in mood following aerobic exercises have been attributed to increases in endogenous opioid release^{57, 58} which play a key role in emotional processing.⁵⁷ The potential of aerobic exercises to trigger positive mood⁵⁸ may be beneficial in managing anxiety and depression which has been found to be prevalent in those living with IBD.^{59, 60}

Additionally, the benefits conferred by resistance training to improve bone mineral density, muscle power and overall functional capacity⁶¹⁻⁶³ may combat low bone mineral density, relieve symptoms such as peripheral joint pain, and fatigue, and improve QoL in individuals with quiescent IBD. Thus, being able to participate regularly in PA may confer these benefits. Our study findings also indicated that adults with IBD value the ability to gain control over their disease by performing PA. This is in agreement with existing research that established that patients' perception of disease control is crucial to them.⁶⁴ As such, designing a useful, feasible, and effective IBD-specific PA program that those affected can utilize fundamental in the overall management of IBD.

Strengths and Limitations

Several studies have called for IBD-specific PA programs.^{21, 65, 66} The findings of this study provide patient-informed design components to incorporate in the development and delivery of such programs. The use of a theoretical framework in this study will potentially facilitate the design of PA programs that have a strong chance of success. A limitation of this study is that

only adults aged 20-45 years old were included to focus on the most common age groups of IBD onset, and only those with access to videoconferencing supports. The preferences of younger and older participants, and those without videoconferencing support might provide other perspectives. We also recognize that COM-B coding involves a degree of subjectivity, and alternative interpretations of the data are possible. Our coding approach was tailored to align with the specific objectives of this study, which may limit its applicability to other research contexts. Despite these limitations, this study provides relevant information for the design and development of PA programs specific to those living with IBD.

Conclusion

Even though IBD poses minimal risk of mortality,⁵ it places a heavy burden on people as it reduces QoL, increases healthcare costs and increases disability in those affected.³ Thus, the need for adjunct therapies like PA, in addition to medical therapies, to manage persistent symptoms and improve QoL cannot be over-emphasized. This study identifies the key factors that need to make up the components of a PA program to facilitate PA behaviour change. We recommend that an IBD-specific PA program should include specific activities and exercises, which can be tailored to each individual based on their IBD symptoms or stage in their IBD journey. This program could be delivered through a phone app to offer ease of access and flexibility of participation, provide opportunity for social support e.g., through an in-app chat group, incorporate knowledge on PA and IBD in formats easily consumed by users, and provide tracking of activities/exercises performed to monitor gains and progress.

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Chapter 5

Study 3: Evaluation of the ‘Active for IBD’ intervention in adults with quiescent inflammatory bowel disease: a feasibility study.

Publication Status:

This manuscript has not yet been submitted for publication.

Citation:

N/A

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Abstract

Background: Increased physical activity (PA) has been identified as one of the beneficial lifestyle behaviours in the management of inflammatory bowel disease (IBD). In this study, we evaluated the feasibility and acceptability of an IBD-specific PA intervention, the ‘Active for IBD’ program.

Methods: The PA program, which incorporated carefully selected exercises, behaviour change strategies, and infographics sharing knowledge on PA and IBD, was delivered via a cell phone application. Adults with quiescent Crohn’s disease (CD) or Ulcerative colitis (UC) performing <150 minutes of moderate to vigorous PA (MVPA) per week participated in the 12-week personalized program, while wearing fitness trackers. Acceptability of the program was assessed via survey. Feasibility outcomes (resources, process, management and scientific outcomes) were assessed as ‘achieved’, ‘revise’ or ‘abandon’.

Results: We planned to enroll 15 participants over 3 months. Six adults were enrolled (female = 4, CD = 5), yielding a recruitment rate of 40%. We collected complete data on five participants (retention rate of 83%). Participants reported that they found the program beneficial (n = 4, 80%) and would recommend the program to others with IBD (n = 4, 80%). 60% strongly agreed/agreed that they found the program easy to use. No adverse or serious adverse events were reported. All feasibility indicators were assessed as either ‘achieved’ (81%) or ‘revise’ (19%).

Conclusion: This study encountered recruitment challenges, however, with modifications, it may be feasible to conduct a larger trial to ascertain the efficacy of this PA program among those with IBD.

Key words: Feasibility, Pilot trial, Quiescent IBD, Physical activity, Fitness trackers.

Introduction

Inflammatory Bowel Disease (IBD), which includes Crohn's Disease (CD) and Ulcerative colitis (UC), is a chronic remitting and relapsing inflammatory condition of the gastrointestinal (GI) tract.^{1,2} In relapse, individuals typically present with symptoms such as diarrhea, bloody stools, abdominal pain, bowel movement urgency, fatigue, nausea and vomiting, and joint pain.³⁻⁵ As symptoms impact quality of life (QoL), symptom control throughout the life course is important for affected individuals.⁶ Standard therapeutic approaches aim to control symptoms predominantly through pharmacological agents.⁷⁻⁹ However, some IBD symptoms have been found to persist even when the disease is inactive, i.e., in the remitting or quiescent phase.¹⁰ While advanced medical and surgical interventions are widely available for the management of IBD,^{7,8,11} adults with IBD often continue to seek adjuvant approaches to alleviate these persistent symptoms and enhance their quality of life.¹²

Multiple patient-related factors, such as diet, psychosocial status, education, and lifestyle behaviors, may influence the therapeutic outcomes of IBD.⁷ In recent years, physical activity has been identified as one of the lifestyle factors associated with health benefits in IBD.^{13,14} Physical activity (PA) is used in this study to refer to all forms of movement involving skeletal muscles, including its subset exercise, which refers to structured and repetitive movements for fitness.¹⁵ PA may be beneficial in IBD because of its effects on the pro-inflammatory cytokines in the GI tract.¹² Additionally, PA mitigates psychological strain in part through the downregulation of stress-hormone pathways.¹⁶

Despite the potential benefits of PA in the IBD population, affected individuals are typically less physically active relative to the general population as they experience additional

barriers related to IBD symptoms including joint pain, abdominal discomfort, bowel urgency and depressive symptoms.¹⁴ Adults with IBD are also burdened substantially by higher occurrence of psychological symptoms, including anxiety, depression and worry due to the unpredictable nature of IBD,¹⁷⁻¹⁹ which have been reported to function as barriers to PA participation.^{20,21}

Existing studies on PA interventions in IBD are heterogenous,²² and reviews on this subject have mixed results,^{12,13} reducing clarity on how to incorporate PA in IBD management. Unlike other chronic disease populations who receive condition-specific exercise prescriptions, individuals with IBD are generally provided with recommendations consistent with those for the general population.¹⁶ Several studies have thus called for IBD-specific PA programs.²³⁻²⁵ To mitigate the gaps in existing research, we developed a PA program specifically for adults with quiescent IBD, with attention to exercise type and symptom-related barriers.

In this study, we investigated the feasibility and acceptability of the ‘Active for IBD’ program in a 12-week non-randomized pilot study (a sub-set of feasibility studies), and its potential impact on persistent symptoms and health-related quality of life (HRQoL). Secondly, we determined if there was increased PA participation at 12 weeks and adherence to PA participation at 16 weeks.

Methods

Study Design: This was a single-arm, non-randomised pilot trial of a PA behaviour change intervention called ‘Active for IBD’.

‘Active for IBD’ is a behaviour change PA program developed by the research group and delivered via both a website and a smartphone application (app) hosted on the LyfeMD platform (Figure 1). The LyfeMD platform²⁶ is a digital health platform designed to help individuals with

IBD optimally manage their disease through lifestyle tools tailored to individual needs. ‘Active for IBD’ was developed from the findings of two previous studies. The first was a systematic review of trials investigating the efficacy of PA interventions in IBD.²² This review investigated the efficacy of PA in IBD and identified the activities and exercises that are beneficial for the alleviation of specific IBD symptoms and improvement of QoL. The second was a qualitative study that explored the barriers and facilitators of PA participation among adults with quiescent IBD, as well as their preferences for PA engagement to inform behaviour change strategies.²⁷

‘Active for IBD’ is made up of three components: 1) PA, specifically, graded aerobic, resistance, and flexibility exercises with accompanying video demonstration; as well as strategies to incorporate PA throughout the day (Appendix I); 2) education on PA, on IBD, and on performing PA while living with IBD; which were delivered within the app via infographics and posters; 3) behaviour change strategies to enhance motivation to perform PA (e.g., social support via chat feature, objective tracking of PA performed, goal-setting, prompts and reminders), to promote opportunity for PA engagement (e.g., delivery through a cell phone app) and to improve capability to perform PA (e.g., incorporating personalization, graded PA and exercises), with the goal of achieving lasting behaviour change towards PA participation (Appendix II).

The PA and exercises incorporated in this program were offered in a graded manner. That is, different levels of PA intensities were included; starting from Level 1 (lowest activity intensity, frequency and time for those performing less than 30 minutes of moderate to vigorous PA [MVPA] per week at baseline) to level 5 (for those who already perform at least 150 minutes of MVPA/week). This was to ensure that users were able to start the program at any baseline level of PA engagement and increase their engagement as necessary.

In the program, recommendations for PA were based on the FITT principle (frequency, intensity, time and type)²⁸. Participants were encouraged to engage in moderate PA three to five times per week for at least 30 minutes, and to increase frequency and time engaged in PA as they could tolerate. Though recommendations were provided, participants were able to personalize the program by, i) selecting the specific type of exercises and activities they preferred among those provided and/or were most suitable for their persistent symptoms (e.g., to avoid high impact exercises if experiencing knee joint pain), ii) performing the activities at the time of the day suitable for them (depending on energy levels that varied throughout the day and from day to day), and iii) performing activities in different locations (home, gym, outdoors, etc.) depending on preferences and/or concerns related to bathroom access.

Study population: We sought Manitobans aged 20 – 45 years, with a confirmed diagnosis of CD or UC, who continued to have ongoing GI symptoms despite clinical remission, and were willing to participate in a PA intervention for 12 weeks while wearing a fitness tracker. They were recruited between May and August 2025. The recruitment period was limited to three months because this study was conducted as part of a PhD thesis.

Eligibility Criteria: Participants were eligible if they had a Harvey Bradshaw Index (HBI) score of ≤ 7 if diagnosed with CD, and Partial Mayo Score (PMS) of ≤ 4 if diagnosed with UC. They had to be on stable maintenance medication for at least six months; with no steroid use, and no IBD-related emergency room visits, IBD-related surgery, or IBD-related hospitalizations. They were required to have a cell phone able to run the two study-related cell phone applications (the LyfeMD app and the fitness tracker app). Individuals who self-reported performing ≥ 150 minutes/week of moderate intensity PA or ≥ 75 minutes/week of vigorous intensity PA, had a

contraindication to exercise training or required a physician's evaluation prior to commencing a physical activity program were excluded.

Sample Size: Calculation of sample size is not a major criterion in pilot studies.²⁹ However, a minimum of 12 participants per group is recommended.³⁰ To account for 20% attrition rate, we aimed to enroll 15 participants for this study.

Recruitment: Participants were recruited from both community and hospital-based gastroenterology clinics in Winnipeg, via a database of individuals who agreed to be contacted for future studies, and through the Crohn's and Colitis Canada – Manitoba (CCC-MB) chapter. Interested participants were assessed to confirm eligibility and screened using the Canadian Society for Exercise Physiology (CSEP - <https://csep.ca>) Get Active Questionnaire, an evidence-based screening tool to identify those who need an evaluation by a physician before engaging in increased PA. This study was approved by the University of Manitoba Health Research Ethics Board. All participants completed and signed the informed consent form.

Consent and enrolment: Eligible participants attended a baseline in-person visit where they signed the consent form, completed questionnaires, set SMART (specific, measurable, achievable, relevant, and time-bound) goals to be achieved in the study, identified preferred PA, and discussed personal coping strategies. Participants were given Garmin Vivosmart 5 fitness trackers to collect PA data throughout the study duration. Baseline PA data were collected in the first 7 days following the visit.

After the 7-day baseline data collection period, participants were invited to a virtual visit via videoconference (Zoom, version 6.3.11) with a member of the research team where they were, i) given access to the 'Active for IBD' app with their personalized PA program embedded;

ii) educated on using the OMNI Rating of Perceived Exertion (RPE) Scale to monitor and regulate their intensity levels while performing PA. They were asked to perform the selected exercises and activities (Figure 2) for 4 weeks after which they were re-evaluated. They were also encouraged to perform other activities if desired.

Follow up: Virtual follow up visits to re-evaluate PA engagement and to complete questionnaires occurred in week 4, week 8 and week 12. At each visit, PA performed, barriers encountered and coping strategies were discussed. Eligibility and willingness to advance to the next level in the program were determined. If advancing to the next PA level, their preferred PA for that level were loaded into their accounts for use over the subsequent 4 weeks. Participation ended at week 12 after which participants no longer had access to the ‘Active for IBD’ program (Figure 3).

Data Collection: Demographic and clinical information were collected at baseline. Capability, opportunity and motivation of participants (COM questionnaire)³¹ and disease activity data (HBI and PMS) were assessed at baseline and at week 12.

- Objective PA data (intensity minutes, daily and weekly steps) were collected weekly using Garmin vivosmart 5 fitness trackers.³² PA data were collected at week 16 to assess adherence to PA behaviour change.
- Assessment of IBD symptoms in quiescent disease, specifically fatigue (Modified Fatigue Impact Scale), joint pain (Patient Reported Arthralgia Inventory), abdominal pain (Numerical Pain Rating Scale 0-10), stress (Perceived Stress Scale-PSS), anxiety (General Anxiety Disorder 7 -GAD-7) and depression (Patient Health Questionnaire - PHQ8), were performed at baseline and every four weeks. We used the GAD-7 and the

PHQ8 because they are brief, validated measures that minimize respondent burden to assess symptoms of anxiety and depression respectively.^{307, 308}

- Health-related quality of life HRQoL (20-item Short Form Health Survey [SF-20]) and perception of IBD control (IBD Control Questionnaire) were also assessed at baseline and every 4 weeks.
- Lastly, social validity of the ‘Active for IBD’ intervention was assessed at week 12 (Social Validity Questionnaire) to determine the acceptability of the study intervention.

Feasibility and evaluation criteria: Following the recommendations of several authors,^{29, 33, 34} feasibility of this study was evaluated for:

1. Resources: To assess cost of study tools, time allocated for study procedures and appropriateness of the tools used in the study (tools used for data collection and data storage).
2. Process: To determine the effectiveness of study methodology including recruitment rates, retention rates, efficiency of data collection and data entry methods (type of data collected, timing between data collection).
3. Management: To assess the efficiency of study processes to achieve study objectives, including staff management, data management and procedures for monitoring and oversight (allocation of duties, reporting procedures, ease of data entry).
4. Scientific outcomes: To determine the safety of the intervention and its procedures (type and frequency of adverse [AEs] and serious adverse events [SAEs], dose escalation).

Feasibility indicators related to each of these four components were evaluated as either ‘achieved’, ‘revise’ or ‘abandon’. Indicators assessed as ‘achieved’ were deemed robust enough and required minimal or no modification for a future trial; whereas those indicators assessed as

‘revise’ needed to be addressed prior to continuing³³ To determine the success of the overall feasibility study, and ascertain if it could proceed to definitive trial, we assessed the overall feasibility outcome as, i) Feasible without modifications (all feasibility indicators assessed as ‘achieved’); ii) Feasible with modifications (all feasibility indicators assessed as either ‘achieved’, ‘revise’ [not more than 30%], and none assessed as ‘abandon’); or iii) Definitive trial not feasible (more than 30% of feasibility indicators assessed as ‘abandon’). ²⁹

Statistical Analysis: Descriptive statistics were used to describe participants’ demographics at baseline. Data are presented as means and standard deviations (SD), median and interquartile range (IQR), and as counts and percentages. Change in PA was assessed using Wilcoxon signed-rank test for non-normally distributed data, paired t-test for normally distributed data, and fisher’s exact test for categorical data. PA participation at baseline, 12 weeks, and 16 weeks are presented as means (SD) or median (IQR). Change in MVPA and persistent symptoms scores over timepoints were assessed by repeated measures ANOVA or Friedman test depending on normality. Paired t-tests or Wilcoxon signed-rank tests were used to compare HRQoL and IBD control scores across the timepoints. Occurrence and frequency of AE and SAEs are presented as counts and percentages. Descriptive statistics were used to summarize social validity and quantitative feasibility indicators.

Results

Demographic information: During the three-month recruitment period, 54 adults with quiescent CD or UC were approached, and two adults from the CCC-MB Chapter contacted the research team for study participation (Figure 4). Of those, six were consented and enrolled. Their age range was 26 – 42 years, 4 were female and 5 were diagnosed with CD (Table 1).

PA Engagement with the ‘Active for IBD’ Program: Of the six enrolled participants, five commenced the study intervention. One participant did not respond to attempts to schedule the first virtual visit. The majority of participants commenced PA participation at level 2 of the ‘Active for IBD’ program (n = 3), others commenced at level 1 (n = 1) and at level 3 (n = 1). Their mean baseline MVPA was 87 ± 13.6 minutes, and median average daily steps was 5518 [Q1-Q3: 4906 - 5983]. At week 12, weekly MVPA was 170 ± 157 minutes, while median average daily steps was 5517 [Q1-Q3: 4435 - 5598] (Table 1 Supplemental Material). IBD symptoms and QoL at baseline and every 4 weeks throughout the intervention duration are reported in Table 2 Supplemental Material.

Acceptability of the ‘Active for IBD’ program: Participants were asked to rate their acceptability of the different components of the study intervention on a 5-point scale ('strongly agree' to 'strongly disagree'). Most participants either strongly agreed or agreed that the program was beneficial for them (n = 4, 80%), liked the features used in the program (n = 4, 80%) and would recommend the program to others with IBD (n = 4, 80%). However, only 60% strongly agreed/agreed that they found the program easy to use, while 40% strongly disagreed/disagreed. Open-ended comments by the participants revealed that the layout of the items in the app were not completely user-friendly; it had “too many extra features that weren't relevant and cluttered the app and made it difficult to navigate”, and “too much jumping around to access/find what you were looking for”. They recommended a “more straightforward, easier layout of the app”, “more common language instead of technical terms, e.g. use ‘workouts’ instead of ‘protocol’”. When asked about the specific components of the program, all participants positively endorsed goal setting, education via posters/infographics and accessing the program via a cell phone app (Table 2).

Feasibility Assessment: A detailed overview of feasibility indicators and how they were assessed is presented in Table 3. In brief,

1. Resource indicators:

- a. The cost of study tools (app development, fitness trackers, Canva subscription for infographics and posters, questionnaires, REDCap for data management) and advertisement efforts were within the set budget (\$13,974).
- b. Time allocated for data collection (1.5 hours for baseline visits, 0.5 hour for follow up visits, approximately 15 minutes for collection of weekly PA data, and approximately 30 minutes for miscellaneous tasks e.g., setting up personalized PA program for each participant) was sufficient.

Resource indicators were assessed as ‘achieved’ except for ‘Study tools’ where the PA app will require modifications before it can be deployed again.

2. Process indicators:

- a. We planned to enroll 15 participants in three months. With all recruitment efforts, 54 potential participants were contacted, two responded to advertisement, and only six were enrolled (40% of set target). Thus, the recruitment goal was not achieved. With the current recruitment plan, it is likely that only 24 participants per site and per year would be recruited. More time, additional recruitment strategies, and/or additional study sites would be required for successful and swift enrolment in a future definitive trial.
- b. One participant did not follow through with participation, but the study retained and collected complete data on the remaining five. A retention rate of 83% (70% target) was achieved.

- c. The timing for data collection (monthly) was deemed appropriate as all five participants completed all the questionnaires in full, promptly, and no complaints were received from participants.
- d. Moderate and vigorous intensity PA minutes/week were collected together on the fitness tracker (i.e., MVPA), and this made it impossible to assess the effect of the two different intensities on IBD symptoms. This was of minimal consequence given the sample size of this pilot study; but with a larger sample size, it might be beneficial to collect moderate PA minutes separate from vigorous PA minutes to perform this sub-group analysis.

Five of the seven process indicators were achieved, two (recruitment rate and type of PA data collected) were assessed as 'revise'.

3. Management indicators:

- a. REDCap was used for data collection and data storage which was optimal. Collecting data from participants via REDCap was efficient, with minimal burden on research personnel.
- b. Procedures for monitoring and oversight were appropriate. The research team held frequent meetings (at least monthly), to discuss research activities, troubleshoot problems and to ensure the study progressed per protocol. All management indicators were 'achieved'.

- ### 4. Scientific outcomes:
- No AEs or SAEs were reported throughout the intervention duration. However, some participants reported physical activity-related complaints. Complaints included right knee pain during squats (week 4 follow up visit), muscle pain during brisk walking which passed after rest (week 4 follow up visit), nausea (week 12

follow up visit) and dizziness while playing badminton (week 4 follow up visit) which did not re-occur. Out of 15 total visits, PA-related complaints were reported by three participants across four visits. Scientific feasibility indicators were ‘achieved’.

All feasibility indicators were assessed as either ‘achieved’ or ‘revise’; none was assessed as ‘abandon’. Out of a total of 16 indicators, three (19%) were assessed as ‘revise’. Thus, overall feasibility for a full definitive trial was deemed ‘Feasible with modifications’. Indicators recommended for modifications are:

- a) ‘Active for IBD’ cell phone app: The layout, labelling and some of the contents of the app will need to be revised to make it more user-friendly and intuitive. This will require changes such as using lay terms throughout the app, adding the option to check off each activity or exercise completed in each session, and removing all unnecessary features such as ‘Bookings’, ‘Modules’ and ‘Protocol’.
- b) Increasing recruitment duration to achieve a larger sample size.
- c) Collecting moderate intensity minutes separately from vigorous intensity minutes to perform sub-group analysis based on PA intensity.

Other items for consideration:

- i. As this was a pilot study, the requirement for staffing was not high. In a larger trial, more staff will be required to execute the different aspects of the study (participant recruitment, database development, data collection, data analysis, and data management).
- ii. More time and associated staff costs might be required for study monitoring and oversight in a larger trial.

Discussion

In this study, we investigated the acceptability and feasibility of an app-based PA program designed specifically for adults with quiescent IBD. Six participants, 40% of the original target, were enrolled during the 3-month recruitment period. One of the six who consented exited the study before commencing the intervention. The remaining five participants completed the study, provided data on all outcome measures, and feedback on intervention acceptability. The majority of participants found the program beneficial, liked the features of the program, and reported they would recommend the program to others with IBD. However, most also found the app difficult to navigate and engage with, recommending changes to improve the utility of the app. Our recruitment objective was not achieved; however, the retention objective was achieved. All resource indicators, specifically cost and time, were achieved except for the 'Active for IBD' app which will require modifications to make it more user-friendly thereby improving its utility. Some process indicators (e.g., recruitment) will require revision; however, all management indicators and scientific outcome indicators were achieved.

The primary purpose of pilot studies is to assess feasibility and prevent the potentially disastrous consequences of launching a large-scale study that could ultimately undermine the entire research effort.²⁹ The findings of this non-randomized pilot study identified components of the study methodology that can be successful in a large trial and also revealed the modifications that need to be made prior to proceeding to a large scale trial to investigate the efficacy of the 'Active for IBD' program. Performing these modifications could prevent waste of research resources in a future larger trial. None of the participants of this study discontinued participation due to an AE, which is in line with previous studies that demonstrate that engaging in PA is safe for adults with inactive IBD.^{22, 35-38} With assurance of safety of PA and the

availability of an IBD-specific PA program, a definitive trial to determine the efficacy of this PA program to improve symptom experience in the IBD population will be a beneficial next step.

Many trials struggle to recruit enough participants³⁹ as we experienced in this study. Attention to recruitment in trials is important because recruitment is essential to program delivery, shaping both individual and population health outcomes.⁴⁰ This study used both active (e.g., contacting potential participants in clinics) and passive (e.g., online advertisement via CCC-MB chapter) recruitment strategies to bolster the success of recruitment efforts. Despite employing multiple strategies, the study recruited 40% of the desired sample size, similar to the trial of Copeland and colleagues.³⁹ This outcome might be because those who commit to PA programs have to be at the stage of change required to take action and we did not specifically seek out those at this stage. Additionally, the study recruited during the summer months when individuals are able to be physically active outdoors, and this might have reduced the number of those willing to participate in the program. Seasonal variation is an important consideration when planning recruitment strategies to maximise recruitment efforts.⁴¹

Recent trials investigating PA in IBD have reported various sample sizes, including 13 participants ages 18 – 40 years enrolled over 10 months,³⁵ 25 participants ages 18 – 60 years⁴² (recruitment duration not provided), 47 participants ages 16 and older enrolled over 14 months,³⁶ 19 participants ages 18 and older (recruitment duration not provided),⁴³ 36 participants ages 16 – 65 years, recruited from three sites over 17 months³⁷ and 32 participants ages 18 years and older recruited over four months from two sites.³⁸ These trials achieved larger sample sizes with extended recruitment periods, wider age ranges and by recruiting from multiple sites.

Mackenzie-Stewart and colleagues⁴⁴ suggested that future studies recruiting participants for PA trials should consider including an assessment of potential participants' stage of readiness

for change. An assessment of the stage of readiness for change of participants in this study revealed that most (60%) participants were ready to be physically active, and were actively looking for ways to do so, and 40% desired to be physically active, but were not making efforts. It is important to note that approximately 22% of those approached were ineligible as they self-reported performing at least 150 minutes of MVPA per week. To improve recruitment success in a future trial, it would be beneficial to employ more passive strategies to attract those in the stage of change for action, increase recruitment duration, increase the number of recruitment sites and remove the age limit, thereby increasing the pool of potential participants.

Strengths and Limitations

This research is unique in that it employed a PA program developed specifically for adults with quiescent IBD. To the best of our knowledge, this is the first study to utilize an IBD-specific PA program that incorporated behaviour change strategies and graded PA/exercise recommendations that can be personalized to reduce barriers to PA participation, to complement existing treatments in the management of quiescent IBD. This pilot study demonstrated clear feasibility objectives and criteria for success of a future definitive trial that other studies can build upon. Additionally, this study utilized objective PA data collected using fitness trackers instead of subjective PA data to enhance the accuracy of the study findings. A limitation of this study is the small sample size and consequent lack of treatment effect. Despite these limitations, the study provides relevant information to facilitate the launching of a larger definitive trial.

Conclusions

PA engagement among adults with IBD can be a valuable adjunct therapy in the long-term management of adults with IBD.^{13,14} With modifications to recruitment strategies and re-designing the PA app, a future larger trial is feasible.

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Table 1: Demographic information of participants

	Overall N = 6
Age, Mean (SD)	33.2 (5.23)
Sex, N (%)	
Female	4 (66.7%)
Male	2 (33.3%)
Marital status, N (%)	
Common-law	2 (33.3%)
Married	2 (33.3%)
Single, Never married	2 (33.3%)
IBD diagnosis, N (%)	
Crohn's Disease	5 (83.3%)
Ulcerative colitis	1 (16.7%)
Smoking status, N (%)	
Current smoker	0 (0.0%)
Previous smoker	0 (0.0%)
Never smoker	6 (100%)
Disease duration, N (%)	
1 - 2 years	2 (33.3%)
More than 5 years	4 (66.7%)
Current medications, N (%)	
5-ASA only	1 (16.7%)
Biologics only	3 (50.0%)
Immunomodulators only	0 (0.0%)
Combination therapy (Biologic + Immunomodulator)	2 (33.3%)

Table 2: Acceptability of the 'Active for IBD' program

	Overall N=5
Related to the 'Active for IBD' Program	
I believe this program was beneficial for me	
Strongly agree/Agree	4 (80%)
Neither agree nor disagree	1 (20%)
Disagree/Strongly Disagree	0 (0%)
I liked the features used in this program	
Strongly agree/Agree	4 (80%)
Neither agree nor disagree	1 (20%)
Disagree/Strongly Disagree	0 (0%)
I found this physical activity program to be an effective additional therapy to my IBD medications to manage my IBD symptoms	
Strongly agree/Agree	2 (40%)
Neither agree nor disagree	2 (40%)
Disagree/Strongly Disagree	1 (20%)
I found the program easy to use	
Strongly agree/Agree	3 (60%)
Neither agree nor disagree	0 (0%)
Disagree/Strongly Disagree	2 (40%)
Overall, I have a positive reaction to the Active for IBD program	
Strongly agree/Agree	3 (60%)
Neither agree nor disagree	2 (40%)
Disagree/Strongly Disagree	0 (0%)
I would recommend this program to others with IBD	
Strongly agree/Agree	4 (80%)
Neither agree nor disagree	1 (20%)
Disagree/Strongly Disagree	0 (0%)
Related to the features of the 'Active for IBD' App	
Prompts and reminders	
Strongly agree/Agree	4 (80%)
Neither agree nor disagree	1 (20%)
Disagree/Strongly Disagree	0 (0%)
Having a personalized set of physical activities/exercises	
Strongly agree/Agree	3 (60%)
Neither agree nor disagree	2 (40%)
Disagree/Strongly Disagree	0 (0%)
Getting knowledge on IBD and physical activities via posters and infographics	
Strongly agree/Agree	5 (100%)
Neither agree nor disagree	0 (0%)
Disagree/Strongly Disagree	0 (0%)
Goal-setting	
Strongly agree/Agree	5 (100%)
Neither agree nor disagree	0 (0%)
Disagree/Strongly Disagree	0 (0%)

Learning coping strategies	
Strongly agree/Agree	4 (80%)
Neither agree nor disagree	0 (0%)
Disagree/Strongly Disagree	1 (20%)
Quizzes	
Strongly agree/Agree	2 (40%)
Neither agree nor disagree	3 (60%)
Disagree/Strongly Disagree	0 (0%)
Receiving the program on a cell phone app	
Strongly agree/Agree	5 (100%)
Neither agree nor disagree	0 (0%)
Disagree/Strongly Disagree	0 (0%)
Getting physical activity monitoring and feedback via the fitness tracker	
Strongly agree/Agree	4 (80%)
Neither agree nor disagree	1 (20%)
Disagree/Strongly Disagree	0 (0%)
Having social support via the 'chat' feature	
Strongly agree/Agree	1 (20%)
Neither agree nor disagree	3 (60%)
Disagree/Strongly Disagree	1 (20%)

Table 3: Feasibility indicators and assessment

Outcome	Objective	Assessment/Measure	Findings	Feasibility evaluation (Achieved/Revise/Abandon)
Resources	To evaluate the cost-effectiveness and appropriateness of the study procedures, tools, and intervention	Cost of advertisement is within budget and acceptable.	Canva subscription to create infographics, posters and advertisement materials cost \$150/year. This was within budget. Advertisement materials were prepared by student researcher, who also performed advertisement activities. There were no associated costs.	Achieved
		Cost of tools related to the intervention is within budget and acceptable.	Fitness trackers: Each Vivosmart 5 fitness tracker cost CAD \$152.50. This was within the budget. Intervention: The ‘Active for IBD’ app cost \$8,650.00. This was within budget.	Achieved
		Time required for study procedures including recruitment, participant enrollment, study visits, data collection and data analysis is reasonable for study staff and participants	Student researcher executed study procedures, no additional staff were hired, thus there were no associated costs. Time required for study procedures was appropriate - 1.5 to 2 hours for baseline visits as planned was adequate. - 30 minutes for follow up visits as planned was sufficient. - Participants completed their questionnaires on their own so no staff-related cost associated with questionnaire completion. - Approx. 30 minutes per participant for communication throughout intervention period (follow up correspondences, scheduling follow-ups, responding to participants’ queries, etc.). This was adequate.	Achieved
		Tools for data collection, storage, retention and analysis are appropriate.	REDCap was used for data capture, data storage and data retention. This was provided by the University at no cost. REDCap worked effectively for data collection from participants, and subsequent storage. Retention of data for 5 years after study completion is at no additional cost. Data capture tool was effective. All study questionnaires captured the study outcomes appropriately. Participants were able to complete them	Achieved

			independently and took approximately 15 minutes to complete all. Questionnaires were adequate. Descriptive data analysis was performed by student researcher and inferential statistical analysis was performed by statistician. Associated costs was within budget. The Vivosmart 5 fitness trackers worked efficiently to collect objective PA data. There were a few instances when tracker did not sync to the 'Active for IBD' app but this was resolved by participants themselves.	
		Study tools (fitness trackers, Active for IBD app, questionnaires) are adequate	The 'Active for IBD' app came loaded with workout videos which participants could choose from to personalize their program; the app has the capability to sync with a variety of fitness trackers including Garmin, Fitbit, apple watch, etc. This was adequate. However, research staff found the app generally hard to work with. The app did not provide reminders to participants to prompt PA behaviour. Student researcher had to create individual 'Tasks' on the app to function as reminders. A task had to be created for each reminder which was time-consuming and not feasible for future use. The App does not have a 'leaderboard', i.e., does not give points or stars for completed activities or goals achieved. The absence of this 'feedback' feature may have reduced the motivation component of the program.	Revise
Process	To assess the effectiveness of study methodology.	Recruitment rate (sample size is achieved within three months).	Enrolment activities occurred between May 8th and Aug 8th, 2025 (3 months). Only 6 participants enrolled out of the 56 who were contacted. More time is required for enrolment as based on the outcome of this study; it is likely that just 24 participants can be enrolled per year at one site.	Revise
		Appropriateness of inclusion/exclusion criteria.	All eligibility criteria were appropriate. However, it might be beneficial to eliminate age restrictions, as imposing an age limit in this study resulted in a decreased pool of eligible participants.	Achieved
		Adequacy of intervention delivery strategies (in-person and virtual delivery).	Baseline visit was completed in-person at the study site. This might have discouraged participation for some potential participants. However, those who participated were determined to participate irrespective of distance to study site. However, if it	Achieved

			is possible to complete everything remotely, that might improve recruitment rates. Delivering the intervention virtually was appropriate. All participants who were committed to study participation provided complete data, attended all virtual follow up visits, and were responsive to communication. Virtual delivery was effective for intervention delivery and data collection.	
		Efficiency of data collection and entry methods (type of data collected, timing between data collection, quality data obtained for analysis)	Using REDCap links to send questionnaires to participants was efficient and reduced burden of data collection and data entry on research staff. Also possibly due to this ease of completion, all participants routinely completed questionnaires. The timing between data collection - monthly - was adequate to assess changes over time.	Achieved
		Appropriateness of type of PA data collected	We collected moderate intensity and vigorous intensity PA together (minutes of each were not differentiated). It would be better to collect moderate intensity minutes separate from vigorous intensity minutes. This would allow sub-group analysis to compare how moderate intensity PA impacts the different outcomes, versus how vigorous intensity PA impacts the outcomes.	Revise
		Retention rates (study retains at least 70% of enrolled participants and collects complete data on at least 80% of participants).	One participant out of six participants did not participate in intake and subsequent study activities after being recruited. The study retained 83% of enrolled participants. Collected complete data on the remaining 5 participants. Thus, collected complete data on 83% of participants.	Achieved
Management	To assess the efficiency of study processes to achieve study objectives.	Staff management: Allocation of duties, staffing issues, ease of data entry, and software capabilities.	No allocation of duties was required as the student researcher was able to manage all study procedures independently due to the small sample size of the study. Additionally, data entry was accomplished quickly and efficiently due to REDCap.	Achieved

		Data management: To assess reporting procedures (data from participants to research staff, adverse events (AE) and serious adverse events (SAE) reporting), data management and software appropriateness.	There were no concerns with data management (collection from participant, storage and retention). AE/SAE reporting was done during follow up visits. Student researcher entered data directly into REDCap during each visit. No challenges were identified with reporting procedures, and REDCap was appropriate for data management.	Achieved
		Monitoring: To assess procedures for monitoring and oversight.	The research group held regularly scheduled meetings to discuss recruitment, enrollment, progress of data collection, etc., and troubleshoot issues arising, to ensure overall study is going per protocol.	Achieved
Scientific outcomes	To assess the safety of intervention and its procedures.	AE and SAE reports.	No AEs or SAEs reported. PA-related complaints include: 002 - week 5 visit: Right knee hurt during squats. All other exercises were fine. 003 - week 5: Reported muscle pain during brisk walking which passed after rest. week 12: Nausea 005 - week 5 visit: Experienced a few instances of dizziness while playing badminton. Participant was educated on the need for hydration. Was advised to report if dizziness re-occurs, lasts up to a minute or increases in frequency. No further reports were made. Of 15 total follow up visits, PA-related complaints were reported at 4 out of 15 visits.	Achieved
		Timing of dose escalation, appropriateness of instruments and outcome measures for the target population.	Participants determined dose escalation, as they were able increase frequency, duration and intensity of activities as they can tolerate. Thus, no concerns related to dose escalation. Questionnaires used for evaluation of IBD symptoms, IBD control and HRQoL were deemed appropriate.	Achieved

Figure 1: Home page - the ‘Active For IBD’ program

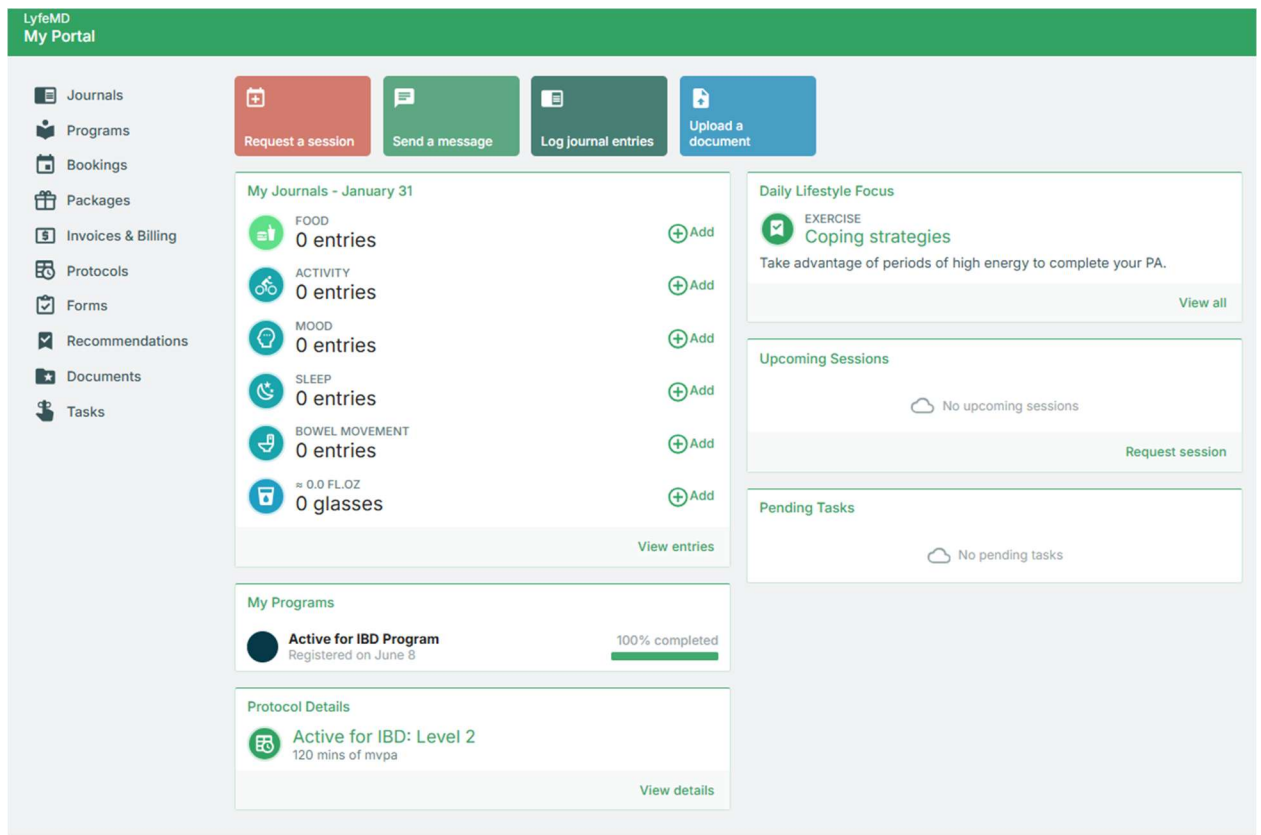


Figure 2: Example of individualized PA program for a participant – Level 2

Protocol Details

Download

Active for IBD: Level 2

120 mins of mvpa

Starts June 18, 2025



Level 2: Exercise Options

Remove (or strike through) exercises that are not selected

PA Level	Warm up	Aerobic Select 5	Resistance Training Select 3	Cool down Select 3
Level 2 Goals: Advance from level 1 to achieve 61 to ≥120 minutes of MVPA/week. Start with 2 sets of the program, then perform additional sets as able within the 4-week duration of the program.	☐ Heel raise x 10-15 reps/min x 2 ☐ Arm cycles x 20 reps ☐ Butt kicks x 20-30 reps ☐ Side stretches (one hand on waist, the other hand reaching upwards and towards opposite side with side-flexion towards side) x 15 reps ☐ Opposite fingers to toes x 25 reps	☐ Brisk walking x 10-15 mins or walking x 30 minutes ☐ High knees x 1.5 – 3 mins ☐ Sit to stand x 18 – 24 reps/min ☐ Lateral shuffle x 20 reps each side ☐ Stairs climbing x 3 – 6 flights of stairs ☐ Dancing x 20 minutes	☐ Wall squats – hold for 30 seconds x 8 – 15 reps (Can progress to Free squats with hands on waist x 8 – 15 reps) ☐ Biceps curls with 5lbs weight/jug of milk (2/3 full) x 8 – 15 reps ☐ Triceps extensions with 5lbs weight/jug of milk (2/3 full) x 8 – 15 reps ☐ Knee push ups x 8 – 15 reps ☐ Standing crunches – opposite elbow to knees x 8 – 15 reps.	☐ Cat stretch + cow stretch x 10 reps ☐ Bridging exercise, hold for 15 seconds x 10 reps ☐ Straddle stretch, hold for 5 seconds x 10 reps ☐ Straddle stretch with side flexion, hold for 30 seconds x 10 reps each side ☐ Trunk rotation in standing x 10-20 reps
Level 2 – Low Motivation or persistent symptoms		☐ Single knee to chest in supine x 10-20 reps each side ☐ Self-paced walking x 15 mins ☐ Marching in place x 2 mins	☐ Side lying leg raise x 8-15 reps ☐ Straight leg raise x 8-15 reps ☐ Bird dog, hold position for 15 seconds x 8 – 15 reps each side	☐ Cat stretch + cow stretch x 10 reps ☐ Straddle stretch, hold for 5 seconds x 10 reps ☐ Standing roll down

Videos/Guidance

Copy and paste exercise instructions here from document provided

Figure 3: Example of participant progression through the program

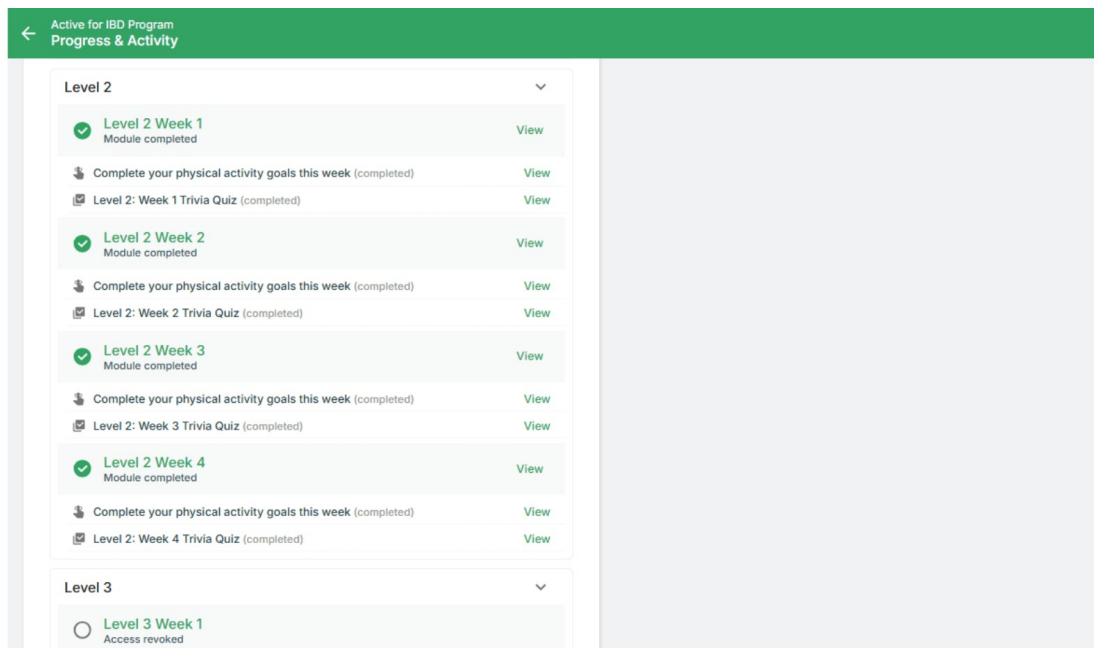
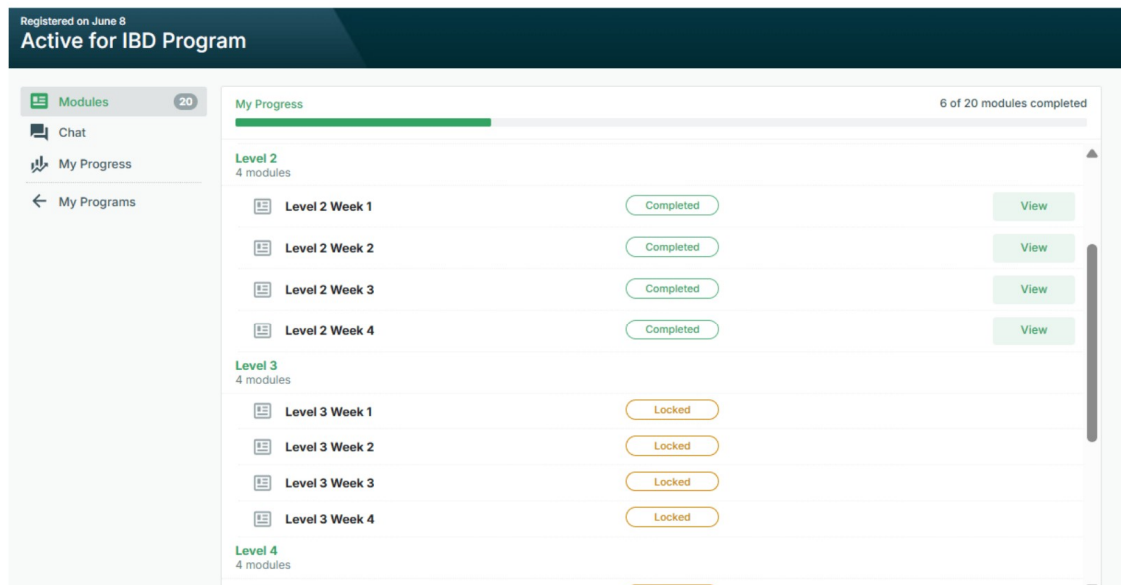
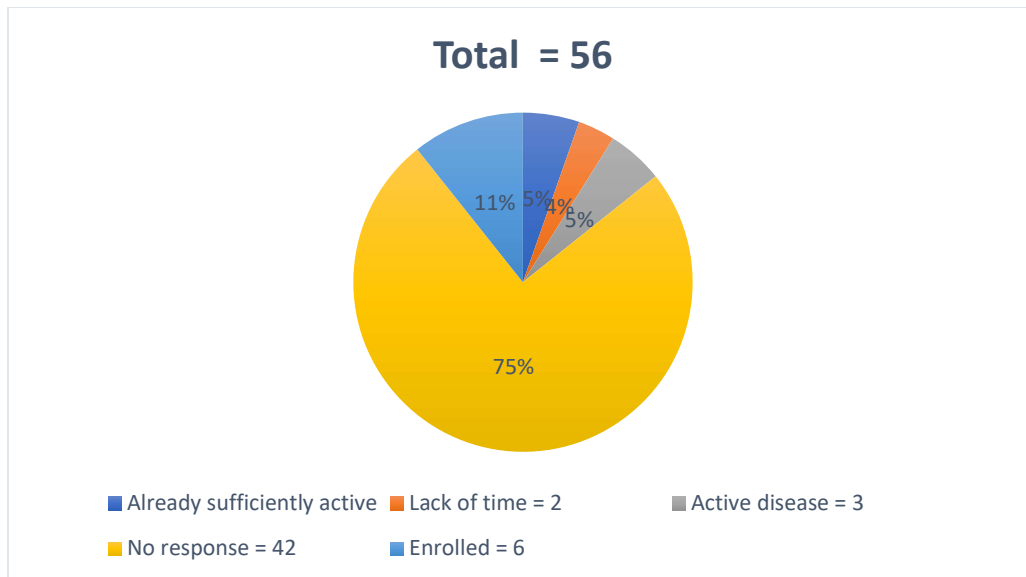


Figure 4: Recruitment



Supplemental Material

Table 1 Supplemental Material: Change in physical activity participation from baseline to 12 weeks.

	Baseline N = 5	Week 12 N = 5	Week 16 N = 5
Intensity Mins (per week) Mean (SD)	87 (13.6)	170 (157)	146.3 (93.1)
Ave Daily Steps Median [Q1 - Q3]	5518 [4906 - 5983]	5517 [4435 - 5598]	3,968 [2741 - 5371]
Steps/week Median [Q1 - Q3]	37,375 [32477 - 38628]	38,625 [31048 - 39188]	24,793 [17561 - 36212]

Table 2 Supplemental Material: IBD symptoms and quality of life pre- and post-
intervention

Variable	Baseline N = 5	Week 4 N = 5	Week 8 N = 5	Week 12 N = 5	MCID^a Achieved or Not Achieved
Disease Activity, Median [Q1 – Q3]	1.00 [1.00 – 2.00]	N/A	N/A	1.00 [1.00 – 2.00]	Not relevant
COM, Mean (SD)	46.6 (10.3)	N/A	N/A	49.2 (12.8)	MCID Not available
Fatigue, Mean (SD)	38.0 (14.2)	38.2 (11.3)	35.2 (13.4)	35.4 (20.3)	Not achieved ^b
Abdominal Pain, Median [Q1 – Q3]	1.00 [0 – 3.00]	1.00 [1.00 – 1.00]	1.00 [0 – 1.00]	1.00 [0 – 2.00]	Not relevant
Joint Pain, Median [Q1 – Q3]	9.00 [1.00 – 33.0]	7.00 [6.00 – 15.0]	2.00 [2.00 – 17.0]	0 [0 – 14.0]	MCID Not available
Stress, Median [Q1 – Q3]	20.0 [19.0 – 22.0]	19.0 [18.0 – 19.0]	19.0 [18.0 – 20.0]	19.0 [19.0 – 24.0]	MCID Not available
Anxiety, Mean (SD)	7.40 (4.10)	7.80 (3.83)	5.60 (3.91)	7.20 (5.22)	Not achieved ^b
Depression, Mean (SD)	8.80 (4.49)	8.80 (4.27)	6.80 (3.90)	8.40 (6.07)	Not achieved ^b
IBD Control, Mean (SD)	12.0 (2.55)	11.6 (3.91)	11.0 (4.95)	12.2 (2.59)	MCID Not available
HRQoL Median [Q1 – Q3]	67.0 [64.0 – 68.0]	66.0 [63.0 – 68.0]	64.0 [63.0 – 65.0]	67.0 [66.0 – 67.0]	Not achieved ^b

^aMCID: Minimal clinically important difference.

^bMCID for this outcome measure is not validated specifically for IBD.

Published MCID thresholds:

1. The Partial Mayo Score for UC disease activity = ≥ 3 points reduction³⁰⁹
 2. Harvey Bradshaw Index for CD disease activity = ≥ 3 points reduction^{310, 311}
 3. Modified Fatigue Impact Scale for fatigue = ≥ 20 points³¹²
 4. Numerical Pain Rating Scale for abdominal pain = ≥ 2 points or $\sim 30\%$ reduction³¹³
 5. Generalized Anxiety Disorder-7 for anxiety = 1.5–2 points or 20–30% reduction³¹⁴
 6. Patient Health Questionnaire-8 for depression = 1.5–2 points or $\sim 20\%$ reduction³¹⁵
 7. SF-20 Health Survey for HRQoL = 5 – 10 points³¹⁶
- No validated MCID threshold was identified for COM questionnaire, the Patient Reported Arthralgia Inventory for joint pain, Perceived Stress Scale and IBD Control Questionnaire.

Disease activity: Harvey Bradshaw index (HBI) for Crohn's disease and Partial Mayo Score (PMS) for Ulcerative colitis. The lower the score, the less the disease activity.

COM Assessment of the Capability, opportunity and motivation of participants to perform PA using the 6-item COM questionnaire. The higher the score, the better.

Fatigue: Modified Fatigue Impact Scale. Highest possible score is 84, with higher scores indicating higher fatigue burden.

Abdominal pain: Numerical Pain Rating Scale 0-10.

Joint pain: Patient Reported Arthralgia Inventory. Higher scores indicate worse arthralgia.

Stress: Perceived Stress Scale (PSS). Total scores range from 0–40, with higher scores indicating higher perceived stress: 14–26 = Moderate.

Anxiety: General Anxiety Disorder - 7 (GAD-7). Scores range from 0 – 21 with higher scores indicating higher anxiety.

Depression: Patient Health Questionnaire (PHQ8). Scores range from 0 – 21; 5-9 = Mild depression

Perception of IBD control: IBD Control Questionnaire. Scores range from 0-16. Higher scores indicate higher disease control.

Health-related quality of life HRQoL: The 20-item Short Form Health Survey (SF-20)

APPENDIX I (Supplemental Material)

The ‘Active for IBD’ PA/Exercises

Personalization:

Participants will be encouraged to participate in a combination of aerobic exercises, resistance training exercises as well as mobility exercises. Activity options will be provided in a graded manner throughout the intervention period using FITT principles (frequency, intensity, type and time). The physical activity (PA) options recommended will be personalized according to the factors below:

1. Persistent symptoms
2. Baseline level of physical activity
3. Physical activity goals
4. Available physical activity supports/resources

*Please note, the columns in the table below are not dependent on each other. Each column simply describes how personalization will be performed based on each category.

Persistent symptoms	Baseline level of PA	Physical Activity Goals	Available resources
Abdominal Pain Joint pain Stress Anxiety Depression Fatigue	Categories of baseline PA levels that will be eligible for the study: 1. Participants with less than 30 minutes of moderate-vigorous physical activity (MVPA) per week at baseline (to start at Level 1). 2. Participants with 31 - 60 minutes of MVPA per week (to start at Level 2). 3. Participants with 61 minutes or more of MVPA (to start at level 3).	Study-specific goals: To get participants to move toward or exceed the Canadian 24-hour movement guidelines for adults aged 18-64 years, and the WHO physical activity guidelines for adults with chronic conditions. Specifically: 1. Increase PA engagement from individual baseline levels of PA to 151 - 300 minutes of MVPA per week. 2. To participate in resistance exercises, with at least moderate intensity, 2-3 days/week. 3. To participate in balance/ mobility exercises 3 – 5 days/week. Participant-specific goals (to be elicited from participants at goal-setting discussions at baseline): 1. E.g., increase walking minutes per day, increase minutes in MVPA, perform more resistance	<u>Physical:</u> Stairs Gym Neighbourhood parks <u>Social:</u> Partner, friends, family, community support groups. <u>Economic/Financial:</u> Gym membership, home workout equipment, etc.



		exercises, perform more repetitions with existing loads, perform resistance exercises with increased loads, perform more flexibility and mobility exercises, etc. 2. Maintain PA levels without regression.	
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Items to Note:

Goal setting and PA level for follow-up visits:

At each follow up visit, participant's PA level will be re-assessed based on data collected on the tracker and downloaded by the research staff to confirm they are able to move to the next PA level. The goals for the subsequent four weeks will also be set. Similar to Week 1 visit, they will be offered PA/exercises in the next level and asked to make their selections. A new PA protocol based on their selections on the level's PA/exercise and goals will be created and added to their account.

Collection of Physical Activity Data:

Baseline PA will be assessed using Garmin Vivosmart 5 fitness tracker (worn for 1 week prior to commencement of intervention). PA data will be collected throughout the study using Garmin Vivosmart 5. Intensity of PA performed will be determined using Heart Rate (HR). Minutes of PA in moderate-vigorous HR zone will be assessed using the Heart Rate Maximum (HRmax) to determine PA performed and goals achieved.

To calculate $HR_{max} = 220 - \text{age}$ (ASCM guidelines¹).

- i. Moderate intensity PA is 64-76% of the participant's HR_{max}
- ii. Vigorous intensity PA is 77-95% of the participant's HR_{max}

For each participant:

1. Calculate the estimated HR_{max} based on their age.
2. Determine the minimum and maximum heart rate targets for the MVPA zone, i.e., heart rate range.

These numbers will be documented for each participant. Inputting this HR zone will be included in the set up of the Vivosmart 5 tracker for each participant to ensure the correct HR zones are tracked.

PA minutes in moderate to vigorous heart rate zone will be collected weekly from Garmin Vivosmart 5 accounts and stored on REDCap.



Physical Activity Options

The exercises below were derived from the 2024 Adult Compendium of Physical Activities for ages 19 – 59 years.²

Note for Aerobic exercises: Participants to document in the diary all other activities and exercises they perform throughout each level such as badminton, basketball, cycling to work, mall walking, treadmill, elliptical, Yoga, Pilates, Salsa, Zumba, Gardening, Carpentry, etc.

Training for monitoring Aerobic training intensity: Educate participants on using the Talk test to monitor and adjust their aerobic exercise intensity. They will be informed that the tracker will use their heart rate to record their PA intensity. Will we also tell them how to check their HR in real time on their tracker and educate them on their intensity zone numbers.

Note for Resistance exercises: At baseline, participants will be educated on how to rate their exercise tolerance using the OMNI scale. They will be encouraged to increase their repetitions if they start rating the exercise as ‘easy to somewhat easy’ after completing their repetitions for the exercise (e.g., add 2 – 3 more repetitions). Participants may be allocated to a resistance training level different from their intervention PA level. Essentially, participants may start at Level 3 but be allocated to resistance training Level 1. The resistance training levels that participants will be put into at baseline will be determined by their self-report of resistance training. Examples:

- If a participant’s baseline levels of PA was ≤ 30 minutes of MVPA with no resistance training at baseline, they will commence at Level 1 with Resistance training Level 1.
- However, if their baseline levels of PA was ≥ 60 minutes of MVPA with no resistance training, then they will start at Level 3 with Resistance training Level 1.
- If a participant reports performing less than 10 repetitions of 2-5 different resistance training exercises on a regular weekly basis, they will be started at Level 2 of resistance training and progressed accordingly. And so on.

PA Level	Warm up	Aerobic Select 5	Resistance Training Select 3	Cool down (Flexibility/Mobility Exercises)
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Physical Activity for Individuals with Quiescent and Mildly active
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				Select 3
Level 1				
Level 1 Goals: • Advance from baseline PA levels to 31 - 60 minutes of MVPA. • Each combination of aerobic exercises = 1 set. • Each combination of resistance exercises = 1 set. <u>Recommendation:</u> a) 20 minutes of MVPA per day; 3 days per week = 60 minutes/week. b) Start with one set of aerobic and 1 set of resistance exercises per session, and progress to 2 sets then 3 sets by the end of week 4. c) Can increase frequency, reps and	☐ Slow walking x 5 mins ☐ Arm cycles x 10 reps ☐ Opposite finger to toe touch x 10 reps ☐ Sit to stand x 6-12 times per minute x 2 minutes ☐ Shoulder rolls x 10-20 reps <u>Note to participants:</u> Walking is the best warm up.	☐ Self-paced indoor walking x 10 minutes ☐ Jumping jacks x 15 - 25 reps ☐ Marching in place x 2 mins ☐ Trunk rotation in standing x 1 – 3 mins ☐ Air punches x 1 - 2 mins ☐ Aerobic dancing x 7 - 10 mins	☐ Bridging exercises (no hold) x 8-15 reps ☐ Sit to stand x 8–15 reps ☐ Wall or counter push ups x 8 - 15 reps ☐ Heel raises x 8 - 15 reps ☐ Assisted squats (hands on chair or back of the couch) x 8 - 15 reps	☐ Cat stretch x 10 reps ☐ Cow stretch x 10 reps ☐ Scapular squeeze x 10-15 reps ☐ Butterfly stretch, hold for 5 seconds x 5 reps ☐ Knee to chest, hold for 5 seconds x 10 reps.



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duration as tolerated prior to follow-up visit.				
Level 1 –Low motivation or presence of persistent symptoms		☐ Slow walking x 5 - 10 mins ☐ Arm cycles x 10 - 20 reps ☐ Opposite finger to toe touch x 10 – 20 reps ☐ Sit to stand x 2 minutes	☐ Toe touch in supine x 8-15 reps ☐ Seated leg raises – hold for 5 seconds x 8-15 reps ☐ Sitting elbow to knee crunches x 8-15 reps	☐ Butterfly stretch, hold for 5 seconds x 5 reps ☐ Knee to chest, hold for 5 seconds x 10 reps.
Level 2				
Level 2 Goals: Advance from level 1 to achieve 61 to ≥ 120 minutes of MVPA/week. Start with 2 sets of the program, then perform additional sets as able within the 4-week duration of the program.	☐ Heel raise x 10-15 reps/min x 2 ☐ Arm cycles x 20 reps ☐ Butt kicks x 20-30 reps ☐ Side stretches (one hand on waist, the other hand reaching upwards and towards opposite side with side-	☐ Brisk walking x 10–15 mins or walking x 30 minutes ☐ High knees x 1.5 – 3 mins ☐ Sit to stand x 18 – 24 reps/min ☐ Lateral shuffle x 20 reps each side ☐ Stairs climbing x 3 – 6 flights of stairs ☐ Dancing x 20 minutes	☐ Wall squats – hold for 30 seconds x 8 - 15 reps (Can progress to Free squats with hands on waist x 8 - 15 reps) ☐ Biceps curls with 5lbs weight/jug of milk (2/3 full) x 8 - 15 reps ☐ Triceps extensions with 5lbs weight/jug of milk (2/3 full) x 8 - 15 reps	☐ Cat stretch + cow stretch x 10 reps ☐ Bridging exercise, hold for 15 seconds x 10 reps ☐ Straddle stretch, hold for 5 seconds x 10 reps ☐ Straddle stretch with side flexion, hold for 30 seconds x 10 reps each side



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<u>Recommendation:</u> 30 minutes of MVPA per day; 4 days per week = 120 minutes/week. Can increase frequency, reps and duration as can be tolerated prior to follow-up visit.	flexion towards side) x 15 reps ☐ Opposite fingers to toes x 25 reps		☐ Knee push ups x 8 - 15 reps ☐ Standing crunches - opposite elbow to knees x 8 - 15 reps.	☐ Trunk rotation in standing x 10-20 reps
<u>Level 2 –</u> Low Motivation or persistent symptoms		☐ Single knee to chest in supine x 10-20 reps each side ☐ Self-paced walking x 15 mins ☐ Marching in place x 2 mins	☐ Side lying leg raise x 8-15 reps ☐ Straight leg raise x 8-15 reps ☐ Bird dog, hold position for 15 seconds x 8 - 15 reps each side	☐ Cat stretch + cow stretch x 10 reps ☐ Straddle stretch, hold for 5 seconds x 10 reps ☐ Standing roll down
Level 3				
Level 3 Goals: -Advance from level 2 to achieve 121 to ≥ 150 minutes of MVPA/week or advance from 60-90 minutes of MVPA to ≥ 150 .	☐ Alternating shoulder elevation and depression x 20-30 reps ☐ Knee push ups, hold for 15 seconds x 10-15 reps	☐ Brisk walking x 30 mins ☐ High knees x 1.5 – 3 mins ☐ Skaters x 15-20 reps ☐ Standing side kicks x 20-30 reps	☐ Bear crawl x 1-2 mins ☐ Planks – hold for 10 seconds x 8 – 15 reps ☐ Free Squats with 5lb x 8 - 15 reps	☐ Triangle stretch, hold for 30 seconds x 10 reps ☐ Straddle stretch with side flexion all the way till head



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- Start with 2 sets of this program, then perform additional sets as able. <u>Recommendation:</u> a) 40 minutes of MVPA per day; 4 days per week = 160 minutes/week. Can increase frequency, reps and duration as suggested and as can be tolerated prior to follow-up visit.	☐ Butt kicks x 25-35 reps ☐ Opposite fingers to toes x 20-30 reps ☐ Jumping jacks x 15-30 reps	☐ Mountain climbers x 15 reps ☐ Wall sit with punches x 15 reps <u>Other options to consider:</u> ☐ Stairs climbing x 6-10 flights of stairs ☐ Dancing x 30 minutes	☐ Woodchop with 5lb x 8 - 15 reps each side ☐ Clamshells in side lying x 8 - 15 reps each side ☐ Scissors (in supine) x 8 - 15 reps	touches shin, hold for 15 seconds x 10 reps ☐ Half split hold for 30 seconds x 10 reps ☐ Heel raise with arms extended above the head, hold for 15 seconds x 10-20 reps
Level 3 – Low Motivation or presence of persistent symptoms		☐ Single knee to chest in supine x 10-20 reps each side ☐ Self-paced walking x 15 mins ☐ Marching in place x 2 mins	☐ Quads sets, hold for 15 seconds x 8 - 10 reps ☐ Bird dog with elbow to knee x 8 - 10 reps each side	☐ Cat stretch + cow stretch x 10-15 reps ☐ Bridging exercises (no hold) x 10-15 reps
Level 4				
Level 4 goals:	☐ Heel raise x 15-30 reps	Any of Level 3 items, plus:	Any of level 3 items, plus:	Any of level 3 items, plus:



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-Maintain achieved PA levels or continue to challenge the body by increasing exercise dose -Participants start with 2 sets of this program, then perform additional sets as able. -Avoid regression.	☐ Wall slides x 5-8 reps ☐ Hip flexor stretches, hold for 30 seconds x 5 reps ☐ Opposite fingers to toes x 20 reps ☐ Jumping jacks x 10 reps	☐ Skip rope x 3-5 mins ☐ Shuttle-running x 5 steps forward\backwards x 10-12 reps, then 5 steps side to side x 10-12 reps ☐ Mountain climbers x 15-30 reps ☐ Cycling 5-10 mph ☐ Jogging x 10 mins	☐ Walking lunges with 10 lb weight\full jug of milk x 8 - 15 reps ☐ Reverse Lunges with 10 lb weight\full jug of milk x 8 - 15 reps ☐ Shoulder tap Planks x 8-15 reps ☐ Squat jumps no weights x 8 - 15 reps	☐ Trunk rotation with knees in flexion x 10 reps ☐ Alternating stationary lunge (one knee flexed, the other extended), hold for 30 seconds x 10-15 reps ☐ Knee to chest in standing, hold for 15 seconds x 10-15 reps ☐ Standing roll down x hold for 60 seconds
Level 4 – Low Motivation or persistent symptoms		☐ Single knee to chest in supine x 10-20 reps each side ☐ Self-paced walking as tolerated ☐ Marching in place x 2 mins	☐ Quads sets, hold for 15 seconds x 8 - 10 reps ☐ Bird dog with elbow to knee x 8 - 10 reps each side ☐ Seated leg raises – hold for 5 seconds x 8-10 reps	☐ Cat stretch + cow stretch x 10-15 reps ☐ Bridging exercises (no hold) x 10-15 reps ☐ Trunk rotation in sitting x 15-20 reps.
Level 5				



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Level 5 goals: -Maintain achieved PA levels or continue to challenge the body by increasing exercise dose. Participants start with 2 sets of this program, then perform additional sets as able. -Avoid regression.	☐ Shoulder circles x 15-30 reps ☐ Opposite fingers to toes x 25 reps ☐ Side kicks x 15 reps each side ☐ Straight leg raise in standing with finger to toe touch x 15-25 reps ☐ Side lunge x 5-8 reps each side	Any of level 3 and 4 items, plus: ☐ Brisk walking x 20-40 mins ☐ Wall squat with air punches x 2-4 mins ☐ Aerobic step exercise x 4-7 minutes	Any of level 3 and 4 items, plus: ☐ Woodchop with 10lb weight x 8 - 15 reps each side ☐ Alternating bent over row x 8 - 15 reps each side ☐ Squat jumps with weights x 8-15 reps	Any of level 3 and 4 items, plus: ☐ Scapular squeeze x 10-15 reps ☐ Butterfly stretch, hold for 15 seconds x 10-12 reps ☐ Knee to chest, hold for 15 seconds x 10-15 reps. ☐ Cat stretch + cow stretch x 8-12 reps ☐ Straddle stretch with side flexion, hold for 30 seconds x 8-12 reps each side.
Level 5 – Low Motivation or persistent symptoms (Same as for level 4)		☐ Single knee to chest in supine x 10-20 reps each side ☐ Self-paced walking as tolerated ☐ Marching in place x 2 mins	☐ Quads sets, hold for 15 seconds x 8-10 reps ☐ Bird dog with elbow to knee x 8-10 reps each side ☐ Seated leg raises – hold for 5 seconds x 8-10 reps	☐ Cat stretch + cow stretch x 10-15 reps ☐ Bridging exercises (no hold) x 10-15 reps ☐ Trunk rotation in sitting x 15-20 reps.



Descriptions for each Level (Provided at the beginning of each Level)

Level 1:

“Welcome to Level 1 of the ‘Active for IBD’ Program. This is a 4-week beginner program to get you comfortable with performing physical activities while living with IBD. This program involves a combination of aerobic exercises, resistance exercises and flexibility exercises, that targets both the upper and lower body. Designed by experts in inflammatory bowel diseases, physical activity and behaviour change, the ‘Active for IBD’ program will help you develop endurance and strength for physical activity in a safe and gradual manner.”

Level 2:

“Welcome to Level 2 of the ‘Active for IBD’ Program. This is another 4-week program to empower you to build upon your physical activity comfort level or level 1. This level of the ‘Active for IBD’ program is also made up of a combination of aerobic exercises, resistance exercises and flexibility exercises. The experts who designed this program designed it with your persistent symptoms and the reality of living with IBD in mind. This program will empower you to achieve more physical activity safely and effectively.”

Level 3:

“Welcome to Level 3 of the ‘Active for IBD’ Program. This is a 4-week program that further challenges you in your physical activity engagement. In this level, you will be encouraged to perform more tasks, for longer durations, and with more repetitions. This might sound scary but know that you are in this level because you are ready for it. This level of the Active for IBD program involves a combination of aerobic exercises, resistance exercises and mobility exercises. The activities in this level have been carefully put together to ensure your physical activity engagement is safe and beneficial for management of IBD.”

Levels 4:



“Welcome to Level 4 of the ‘Active for IBD’ program. Congratulations on the progress you have made to achieve your physical activity goals and now ready to maintain those goals or challenge yourself even more. In this level, you will be provided with tools to keep you consistent with your physical activity participation and get you to push your body a bit more if desired. You have selected the activities of your choice, and you are completely in control. You can do this!”

Level 5:

“Welcome to Level 5 of the ‘Active for IBD’ program. Congratulations on achieving your physical activity goals and maintaining those goals. In this level, you will be provided with tools to keep you consistent with your physical activity participation or get you to push your body even more. You are unstoppable!”

References:

1. American College of Sports Medicine. (2013). *ACSM's guidelines for exercise testing and prescription*. Lippincott Williams & Wilkins.
2. Herrmann SD, Willis EA, Ainsworth BE, Barreira TV, Hastert M, Kracht CL, Schuna Jr. JM, Cai Z, Quan M, Tudor-Locke C, Whitt-Glover MC, Jacobs DR. [2024 Adult Compendium of Physical Activities: A third update of the energy costs of human activities](#). *Journal of Sport and Health Science*, 2024;13(1): 6-12.



APPENDIX II (Supplemental Material)

‘Active for IBD’ Program - Behaviour Change Strategies

Problem Behaviour: Low physical activity engagement by individuals with IBD.

Existing research indicates that adults with quiescent inflammatory bowel diseases (IBD) do not engage optimally in physical activity (PA) as recommended in the Canadian 24-hour Movement Guidelines for adults.¹ This behaviour, low PA engagement by individuals with quiescent IBD, is the ‘problem behaviour’.

Target Behaviour: Consistent PA engagement by adults with quiescent IBD.

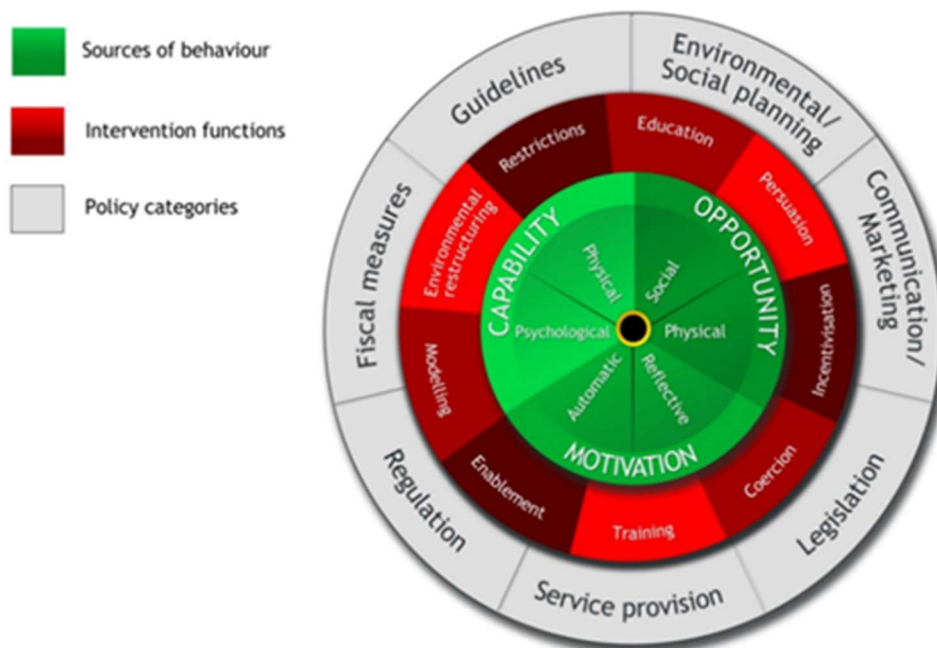
The study intervention aims to change the problem behaviour in individuals with quiescent IBD, to facilitate consistent PA engagement to potentially meet the Canadian 24-hour Movement Guidelines for adults and the WHO 2020 Guidelines on PA and sedentary behaviour² for adults with chronic conditions.

The behaviour change component of the study intervention was developed from the findings of the qualitative study. The aim of the qualitative study was to understand the problem behaviour, identify the components that need to change and the intervention functions that can facilitate that change, to achieve the target behaviour. The COM-B model was used to analyze the study data and organize the study results. Consequently, the barriers to, and facilitators of the target behaviour in adults with quiescent IBD were organized according to capability, opportunity and motivation components.

The COM barriers and facilitators were then mapped to the Behaviour Change Wheel (BCW)³ to identify the intervention functions that can address or enhance them. Intervention functions relevant to this study that were identified in the BCW are listed in the table below:

Capability:	Opportunity	Motivation
Education	Education	Coercion (create an expectation of punishment or cost)
Environmental restructuring	Persuasion (use communication to stimulate action)	Enablement (remove barriers/enhance facilitators)
Modeling	Incentivization (create an expectation of reward)	

The BCW:



The BCT Taxonomy

For behaviour change to be beneficial, the active ingredients of behaviour change, i.e., behaviour change techniques (BCTs), should stem from theoretical constructs.⁴ Therefore, after identifying

the requisite intervention functions in the BCW, I used the BCT Taxonomy V1,⁴ to identify the appropriate BCTs relevant to each theory construct.

Capability	Opportunity	Motivation
Education: - Shaping Knowledge - Information about health benefits and consequences.	Education: - Credible source - Pros and Cons	Coercion *Provided as part of Education.
Environmental restructuring: - Restructuring of the physical environment. - Problem solving (create personalized coping strategies)	Persuasion - Self-belief - Valued Self-identity - Self-Monitoring of Behaviour	Enablement - Social Support - Habit Formation - Feedback on outcomes of behaviour
Modeling: - Modeling - Goal setting - Graded tasks	Incentivization - Action Planning - Material Incentive	

COM constructs, Intervention Functions and BCTs

The facilitators and barriers of PA listed below are drawn from the findings of the qualitative study. The intervention functions derived from the BCW and qualitative study findings, and the BCTs that will constitute the behaviour change intervention are also listed below (in purple).

Domain	Facilitators (Identified from the qualitative study)	Barriers (Identified from the qualitative study)	Intervention Functions (from the BCW and qualitative study) • BCTs
Capability	<u>Physical capability</u> a) Physically active prior to diagnosis. b) Creating coping strategies and positive health behaviours, including prioritizing optimum nutrition and sleeping.	<u>Physical capability</u> a) IBD Symptoms including abdominal pain, fatigue and joint pain <u>Psychological capability</u>	Education: - Shaping Knowledge - Information about health benefits and consequences. Environmental restructuring: - Restructuring of the physical environment. - Problem solving (create personalized coping strategies)

	<u>Psychological capability</u> a) Having positive attitude towards PA, including awareness and understanding of the limitations of living with IBD. b) Maintaining a PA routine.	a) Unpredictability of living with IBD, which is disruptive to having a routine. b) IBD-related symptoms including depression and anxiety.	Modeling: - Modeling of PA and exercises. Others: - Goal setting - Graded tasks
Opportunity	<u>Physical Opportunities</u> a) Individualized PA program (flexibility in participation). b) Accessible work out spaces. c) Type of employment <u>Social Opportunities</u> a) Social circumstances including presence of an accountability partner or accountability community, social support from family and friends to promote PA engagement. b) Enjoyable PA programs and engagement opportunities.	<u>Physical Opportunities</u> a) Financial constraints b) Time constraints c) Weather. <u>Social Opportunities</u> a) Lack of social support needed for PA engagement.	Education: - Credible source - Pros and Cons Persuasion - Self-belief - Valued Self-identity - Self-Monitoring of Behaviour Incentivization - Action Planning (Individualized PA program) - Material Incentive (free access to the PA app and intervention resources) - Social support (within the app)
Motivation	<u>Automatic Motivation</u> a) A routine/program of enjoyable PA b) Discipline/persistence. c) Social support d) Access to tracking of progress.	<u>Automatic Motivation</u> a) persistent IBD symptoms b) weather c) work-related tiredness. <u>Reflexive Motivation</u>	Coercion *Provided as part of Education. Enablement - Social Support (within the app and from family/friends) - Habit Formation - Feedback on outcomes of behaviour Others: - Knowledge



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	<u>Reflexive Motivation</u> a) Performing PA to distract from the symptoms of IBD b) Maintaining awareness of limitations presented by persistent symptoms (and adjusting accordingly both mentally and physically) - Knowledge c) PA recommendation from trusted sources d) Personal goals	a) Need for accessible bathrooms b) Concerns about body image	
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BCTs and how they will be applied:

1. Education:

- a. Shaping Knowledge: Knowledge on IBD, engaging with PA while living with IBD, the need for behaviour change, safety of PA for those with IBD, movement guidelines, existing research on the potential effect of PA on persistent symptoms, available resources in MB (Psych health supports, IBD nurse, dietitian, CCC-MB chapter, etc.)
- b. Information about health consequences: Share information on benefits of PA generally, benefits of PA for individuals with IBD, consequences of lack of PA engagement generally and in chronic conditions, IBD and smoking, IBD and immigration, prioritizing optimum nutrition, PA participation following IBD diagnosis, etc.
- c. Credible source:
 - i. Highlight members of the research team as the intervention's designers; share research team qualifications at baseline.
 - ii. Sources of information will accompany the education blasts provided (references, links, organization name, etc.)
 - iii. Share details on CCC-MB chapter and resources originating from the organization.
- d. Pros and Cons: Educate on benefits of changing behaviour and performing more PA, as well as consequences of not performing PA, from existing research.



All these will be provided via infographics, posters and quizzes within the LyfeMD app.

- i. 3 infographics/pamphlets will be shared on the app per week. These will also function as prompts and cues.
 - ii. One set of quizzes per week (each quiz will comprise 3 questions on IBD, PA and behaviour change).
2. Environmental Restructuring:
 - a. Restructuring the physical environment: This will be personalized.
 - i. Example, lay out workout clothes before going out in the morning, place weights by the television, etc. to provide cues for PA engagement.
 - ii. Additionally, increase cues for target behaviour - by providing PA prompts, reminders, trivia related to PA and IBD, infographics/posters promoting PA performance.
 - iii. Problem solving to create individualized coping strategies to manage persistent symptoms and other barriers to PA engagement: Potential strategies will be discussed at the baseline visit and at follow-up visits.
 - iv. At baseline visit, brainstorm potential coping strategies with participant.
 - v. Encourage taking advantage of periods of high energy to get PA done. Also provide regular reminders about this in the app.
3. Modeling:
 - a. Modeling:
 - i. Exercise videos will be provided in the app to demonstrate correct performance, posture and form.
 - ii. Personalize activities and exercises to specific persistent symptoms – detailed in PA/exercise component.
4. Others:
 - a. Goal setting:
 - i. SMART goals will be set in collaboration with the participant at baseline and follow-up visits.
 - ii. Problem solving strategies so as to achieve set goals will be discussed at each study visit; including - find the location of bathroom first upon entering a gym or a park the first time, don't work out too far from the bathroom, identify bowel movement triggers, select less stressful activities when fatigued. Additionally, discuss individual barriers and potential solutions.
 - b. Graded tasks: Participant's individual PA goals will be broken down into easy-to-perform tasks, which will progress with increasing difficulty until the target behaviour is achieved or maintained. The PA program will be provided in levels



so that each participant can commence the intervention at the level suitable to their baseline level of physical activity.

5. Persuasion (to use communication to stimulate action):
 - a. Self-belief: This includes verbal persuasion about participant's own capabilities, promoting self-talk and highlighting past successes with performing PA.
 - b. Valued self-identity: Encourage participants to detail personal strengths at research visits; review previous gains and goals achieved at follow-up visits. These will be achieved via ongoing discussions at baseline and follow-up visits.
 - c. Self-Monitoring of behaviour: Participants will be given smartwatches so they can objectively track their PA engagement and goals achieved.
6. Incentivization:
 - a. Action Planning:
 - i. This will be achieved by personalizing the PA/exercises recommended to each participant. Personalization will be achieved using the individual's persistent symptom(s), baseline level of PA, available physical and social resources and personal goals. The personalization details will be discussed at baseline and follow-up visits, after which the relevant PA/exercises will be set up and made available to them through the app.
 - ii. Brainstorm resources available to participant at intake visit.
 - iii. Encourage flexibility with PA participation – daytime or nighttime, gym or home, etc.
 - iv. If no access to work-out equipment, encourage use of body weight, milk jugs, cans of food, etc. for resistance training.
 - b. Material Incentive:
 - i. Free access to the app and other intervention-related resources.
 - ii. In-app trophies will be awarded for tasks completed, quizzes completed, infographics/pamphlets viewed, and goals achieved.
7. Coercion: To be provided as part of education.
8. Enablement:
 - a. Social support:
 - i. Provided via the in-app support group (chat group). Encourage participants to discuss their symptoms, coping strategies, uncommon symptoms they recently noted, reactions to a particular exercise, encouragements, etc.
 - ii. Participants will be encouraged to leverage using family and friends to keep them accountable to their PA goals.
 - b. Habit formation:



- i. Streaks: Gamifying performance of PA through the app, to hopefully create a routine.
 - ii. Also, encourage habit formation using weekly trivia, completing weekly or daily goals, and awarding trophies for targets/goals completed.
 - iii. Pop-up notifications in app for extra points, e.g., “Complete 10 extra minutes of brisk walking and collect 2 trophies.”
- c. Feedback on outcomes of behaviour:
 - i. This will be achieved through goal-setting discussions at follow-up visits.
 - ii. Changes in the scores of outcome measures will be reviewed with participant at each follow-up to assess changes in symptom impact/severity and quality of life following PA engagement.

****Outcome Measure to assess the effectiveness of behaviour change intervention: The COM questionnaire.**

Social Support Monitoring Plan

The support group is meant to be a safe space for participants to share experiences, coping strategies, learn from each other and offer support to each other. To ensure the support group is safe, no personal health information (PHI) is shared, as well as to ensure there is no misinformation, we will have the following in place:

1. At baseline:
 - a. Student researcher will provide thorough explanation of the purpose of the group chat (for social support and not for sharing medical information), provide the do's and don'ts, and importance of safety for all participants.
 - b. All participants will be given a one-page 'disclaimer' detailing the rules guiding the use of the support group. This will be signed by participants at the start of the study.
2. Daily monitoring of the chats will be conducted. Any inappropriate information will be promptly deleted.
 - a. If any participant expresses distress in the chats, the participant will be contacted privately to facilitate prompt referral to appropriate healthcare professionals.
3. Anyone who breaks any of the rules in the disclaimer up to three times will be removed from the support group. Any participant found breaking any of the rules will be offered warning. A third occurrence will lead to removal from the support group (not the study).



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Chapter 6: Thesis Synthesis and Conclusion

Thesis Synthesis

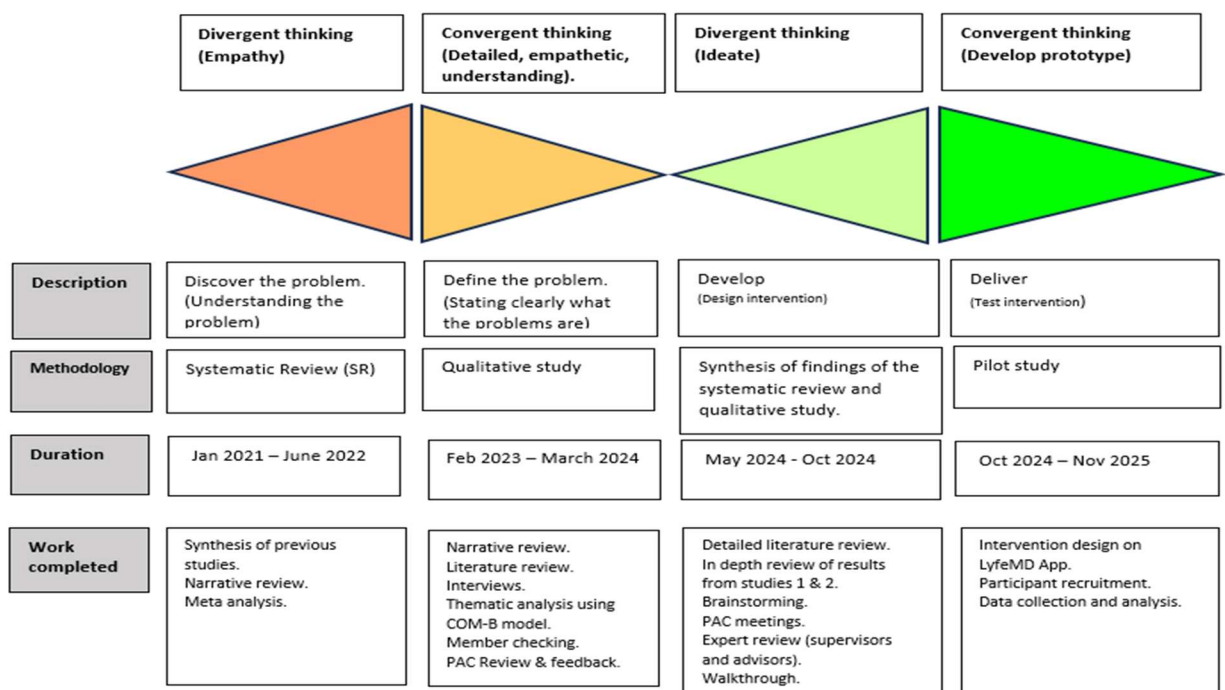
IBD is a life-long condition without a cure, and many of those affected require ongoing medications to maintain remission ¹. Adults living with quiescent CD or UC often experience persistent IBD symptoms such as fatigue, abdominal pain and urgency, and psychological symptoms such as depression, anxiety and stress ²⁻⁵, which impact on their HRQoL ⁶⁻⁸. Hence, there is a need for evidence-based adjunct therapies in addition to medical therapy to manage their disease and improve their HRQoL ⁶⁻⁸. The International Organization for the study of Inflammatory Bowel Disease recommendations list specific environmental and lifestyle factors that improve the natural history of IBD including, cessation of smoking, regular screening for psychosocial stressors with appropriate referral, diet, and encouraging regular PA ⁸. Despite the important role that regular PA may play in improving clinical outcomes for adults living with IBD ^{2, 7, 64}, previous research indicates they do not perform recommended levels of PA to gain the benefits ⁷. Furthermore, PA guidelines specifically for adults with IBD are lacking ¹⁴⁰. This thesis addressed this problem by reviewing the literature on the effects of PA on IBD symptoms, investigating the cause of low PA participation in this group and designing an IBD-specific PA program for the management of persistent symptoms in a subset of adults with quiescent and mildly active IBD. To the best of my knowledge, this is the first PA program designed specifically for adults with quiescent and mildly active IBD, and incorporated behaviour change strategies that are relevant to those living with IBD.

The thesis was fulfilled by three research objectives, guided by the knowledge to action (KTA) framework. The objectives were:

1. To determine existing knowledge about the safety and efficacy of PA as adjunct therapy to medical therapy, compared to medical therapy alone for alleviation of ongoing symptoms and improvement in HRQoL in adults with quiescent IBD.
2. To explore patient experiences with PA, as well as barriers and facilitators of PA participation among adults (age 20 - 45 years) with quiescent IBD who continue to experience persistent symptoms.
3. To investigate the feasibility of an individualised PA behaviour change intervention designed for adults (age 20 - 45 years) with quiescent and mildly active IBD for a future large trial.

I employed the Double Diamond Design Thinking framework in the overall design process. As depicted in figure 5 it offered an innovative way to develop solutions and interventions that address complex needs of individuals within the healthcare system ²⁹⁹.

Figure 5: Thesis Double Diamond Design Thinking Process.



The first research objective was ‘to determine existing knowledge about the safety and efficacy of PA as adjunct therapy to medical therapy, compared to medical therapy alone for alleviation of ongoing symptoms and improvement in HRQoL in adults with quiescent IBD’. Within the Double Diamond Design Thinking framework, this phase of the thesis utilized the first diamond and focused on ‘Discover’, i.e., performed a deep dive into the problem. This initiated the divergent thinking process.

I started with knowledge synthesis which, within the knowledge to action framework, is crucial to generate evidence-informed knowledge, identify gaps in research as well as the know-do gap (i.e., the gap that exists between the availability of knowledge and the application of that knowledge). To evaluate the current evidence regarding the safety and efficacy of PA in reducing symptoms and improving HRQoL among individuals with quiescent IBD, as well as to identify activities and exercises that are beneficial for specific persistent IBD symptom, I completed a systematic review (chapter 2). Of the retrieved citations, seven RCTs and one non-RCT were included in the review, highlighting that RCT-level research evaluating PA interventions in quiescent IBD is lacking. Additionally, the available trials were methodologically heterogeneous, making it challenging to determine consistent benefits of PA for adults with IBD. This absence of definitive evidence on specific PA engagement recommendations, including intensity, frequency and duration of activity, may have contributed to the poor PA participation reported among individuals with IBD. Moreover, previous studies reveal that knowledge on PA, recommendations for participation and professional guidance are relevant to facilitate PA engagement^{317, 318}.

On an encouraging note, results from the included studies in this review indicated that PA can be performed safely by individuals with quiescent or mildly active IBD. Furthermore, we

were able to identify several activities that could be performed safely by adults with quiescent IBD, which could also alleviate some persistent IBD symptoms. We also identified gaps in research assessing the efficacy of PA in improving health-related quality of life and addressing specific persistent symptoms in quiescent or mild IBD. Rigorous and larger RCTs are needed to investigate efficacy and provide evidence-informed recommendations to individuals living with IBD.

The second research objective was ‘to explore patient experiences with PA, as well as barriers and facilitators of PA participation among adults (age 20 - 45 years) with quiescent IBD who continue to experience persistent symptoms.’ This phase of the research program completed the processes within the first diamond, i.e., divergent thinking. This step helped me ‘Define’ the problem to have a clearer understanding to focus on solutions and outcomes for this research. This involved exploring the problem in a detailed and empathetic manner, using qualitative methods to understand the needs of individuals with quiescent and mildly active IBD, their socioeconomic and psychosocial environments and other factors that may influence the value a PA intervention may offer them. With the involvement of patient partners, we explored study findings and developed conclusions based on data (Define).

In keeping with the knowledge to action framework, in this phase I explored in-depth the barriers and facilitators to the use of the knowledge synthesized in the systematic review (i.e., low PA participation) and elicited strategies to tailor and individualise available evidence on PA in the IBD population. Using a qualitative description study (chapters 3 and 4), Manitobans 20 to 45 years old with quiescent IBD who continued to experience some persistent IBD-related symptoms were interviewed to get their perspectives. Barriers to PA participation elicited

included ongoing IBD-related persistent symptoms, low or no PA engagement prior to IBD diagnosis, lack of social support, poor bathroom access, lack of financial support, and lack of knowledge on PA engagement while living with IBD. Facilitators for PA engagement included being physically active prior to IBD diagnosis, having coping strategies, availability of social support, optimal bathroom access in workout spaces, having employment that involves a lot of physical activity, availability of relevant knowledge on PA, adhering to a PA routine, and ability to track progress achieved via gadgets and apps.

As the goal of this thesis was to design an intervention, using the COM-B model ²⁵⁰, I explored factors that are crucial for the design of the program from end users' perspectives. Three main themes were identified through thematic analysis: 1) incorporate personalization, include supervision and knowledge on PA and IBD to increase capability for PA participation, 2) deliver the program using a cell phone application to promote opportunity for engagement, and 3) incorporate social support, PA engagement tracking and minimize program barriers to enhance motivation for PA. Next, I mapped the barriers and facilitators to intervention functions using the Behaviour Change Wheel (BCW) ²⁵⁰. This was completed to identify behaviour change strategies to incorporate in the intervention. For example, 'knowledge' was mapped to 'Education, specifically, shaping knowledge and providing information about health benefits and consequences.' Fulfilling this second research objective provided more clarity on the factors that influence PA behaviour among adults with quiescent IBD.

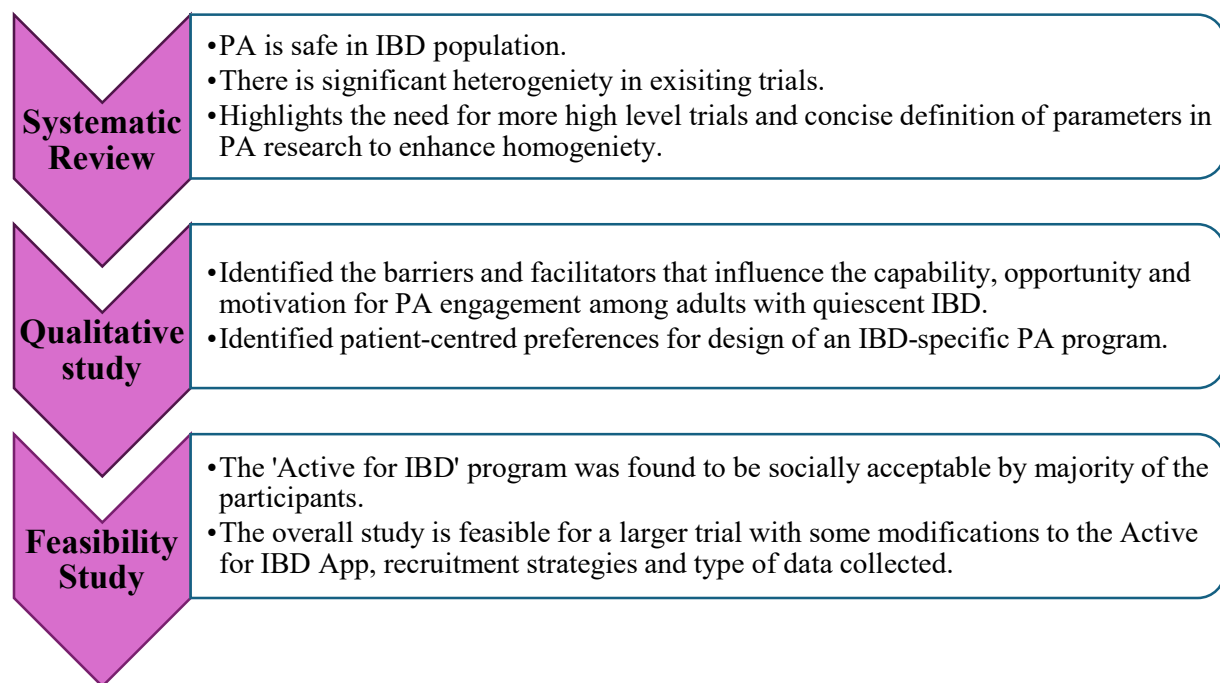
The final research objective was 'to investigate the feasibility of an individualised PA behaviour change intervention designed for adults (age 20 - 45 years) with quiescent and mildly active IBD for a future large trial.' This phase of the research initiated the second diamond with

the goal of ideating, i.e., using divergent thinking to design the intervention (Develop). In collaboration with patient partners and the thesis committee, the PA intervention was designed using data from findings of projects associated with the first and second research objectives. In the KTA framework, this step is to adapt the previously generated knowledge to the unique characteristics of adults with quiescent IBD and perform knowledge inquiry. The intervention was comprised of three key components: 1) knowledge on PA, IBD and performing PA while living with IBD (see Appendix VI of thesis); 2) carefully selected PA and exercises, with a focus on personalization, goal setting and progression of the activities and exercises deemed safe and beneficial for specific persistent symptoms (see chapter 5, appendix I); and 3) behaviour change strategies to facilitate PA engagement and reduce barriers to participation (see chapter 5, appendix II).

To complete the diamond, convergent thinking was employed to finalize the intervention and launch it via a cell phone application (Deliver). The intervention, called the ‘Active for IBD’ program, was housed on the LyfeMD platform ³¹⁹ which is a cell phone app to facilitate users’ engagement with the intervention. The acceptability and feasibility of the IBD-specific PA intervention was investigated in a 12-week non-randomized pilot trial (chapter 5). The study yielded a recruitment rate of 40%, a retention rate of 83%, and 81.25% of all feasibility indicators were achieved. The majority of participants (60%) strongly agreed/agreed that they found the program easy to use, however the remaining 40% strongly disagreed. While the majority of participants reported that they found the program beneficial (80%) and would recommend it to others with IBD (80%), they made recommendations to improve the program. Their recommendations included having a better layout for the app and making it more user friendly, using lay terms for labelling items on the app (e.g., using a different word to label PA

and exercise page instead of the word ‘protocol’), and removing all redundant features (e.g., ‘bookings’). They also suggested adding some features such as the option to check off activities or exercises completed, adding a timer for activity duration, and including the suggested number of repetitions to be completed in each exercise video. With the updates to the app and adjustments to recruitment strategies, a large definitive trial is feasible.

Figure 6: Flow chart of key findings of the three phases of the research program



Knowledge Translation:

A range of knowledge translation products can be developed from this research program to support the uptake and application of its findings. These include:

1. Evidence-informed clinical summaries for healthcare providers: A concise, practice-ready brief summarizing the safety, potential benefits, and barriers of PA participation in

quiescent and mildly active IBD. This can reduce the know-do gap by giving clinicians guidance on PA recommendations despite heterogeneity in research.

2. Patient-facing educational toolkits on PA in IBD: A set of accessible materials such as infographics, FAQs, symptom-specific PA suggestions, etc., explaining safe PA options, benefits, the adverse events to look out for when performing PA and strategies to overcome common barriers. This can help address knowledge gaps among individuals living with IBD and empower those interested in PA engagement.
3. Active for IBD Program Manual: A structured manual describing the intervention components, personalization pathways, exercise progressions and behaviour change techniques. This can enable replication, adaptation and integration into future trials.
4. Upgraded Active For IBD Program: A refined version of the intervention incorporating participants' feedback (e.g., lay language, removal of unnecessary components, check-off feature). This will provide a scalable, user-friendly digital tool that supports real-world PA engagement.
5. Academic KT outputs: In addition to the published systematic review and qualitative study manuscript, the second qualitative study manuscript and the feasibility study will be published. Opportunities to present the results of this thesis in conferences will be sought. Opportunities to present webinars for clinicians or patient groups may also help bridge the know-do gap.
6. Community or Patient Organization Resources: User friendly materials co-developed with Crohn's and Colitis Canada – Manitoba chapter or similar groups (e.g., PA starter guides, symptom-specific exercise suggestions). This can help broaden reach and support community-level adoption.

Together, these products can help bridge the know-do gap, support future implementation and evaluation of IBD-specific PA interventions, with the overall goal of enhancing PA engagement among individuals with quiescent IBD.

Contributions to Research

Considering the likelihood of therapeutic limitations to eradicating symptoms in individuals with IBD and the frequency and intensity of side effects of medications, incorporating adjunctive therapies such as routine PA can contribute meaningfully to the overall management of the condition ³²⁰. The WHO recommends that adults with all chronic conditions participate in at least 150 – 300 minutes of moderate intensity PA or 75 – 150 minutes of vigorous intensity PA each week to improve QoL, reduce the rate of disease progression and contribute to healthy aging ²⁶. This was also echoed in the Canadian 24-hour movement guidelines ³²¹ that adults 18-64 years of age perform at least 150 minutes of moderate to vigorous physical activities each week. A knowledge gap persists regarding the potential role of PA and the optimal approaches for integration within current medical options ³²⁰. Several previous research studies have called for IBD-specific PA programs ^{28, 317, 318}. This thesis adds relevant data to fill current gaps in research on incorporating PA as an adjunct therapy in IBD, by providing an IBD-specific PA program which incorporates personalization and behaviour change strategies so that those living with IBD may also achieve recommended levels of PA.

Patients with IBD increasingly use adjunctive therapies like routine personalized PA, albeit with lack of guidance on dosage, i.e., type, intensity, frequency and duration ³²². This thesis contributes to the ongoing research to reduce confusion for adults with quiescent IBD through development of the ‘Active for IBD’, an app-based PA program with recommendations of exercises and activities, dosage and dose escalation, which can be personalized to specific

persisting IBD symptom(s) and the unpredictability of the disease. Similar intervention studies investigating PA in IBD have utilized a variety of PA programs including gym-based moderate intensity combined aerobic and resistance exercise programs ³²³, personalized aerobic and progressive-resistance training ³²⁴, supervised moderate-intensity running ³²⁵, detailed instructions on moderate aerobic endurance and moderate resistance training ¹³⁰, and 10-minute videos of abdominal exercises inspired by Yoga ³²⁶. However, to the best of our knowledge, this current study is the first to incorporate patients' voices and research-informed PA and exercises in the design of the PA intervention which users can personalize based on their preferences and IBD symptoms. More importantly, the feasibility of conducting a large-scale trial using this intervention and methodology has been assessed and deemed feasible with some modifications.

Strengths and Limitations

The development of an IBD-specific PA intervention offers researchers a feasible intervention to incorporate into an RCT. Further, this reduces the need to include diverse PA programs in future trials by offering a template for building other programs; thereby reducing the heterogeneity on this subject. This study demonstrates that the development of PA programs that end users will find beneficial to improve their clinical course should be grounded in mixed methodologies to enhance the quality of study outcomes. A key strength of this thesis is the incorporation of a systematic review of existing evidence and theory-based qualitative methods to inform the design of the 'Active for IBD' program. Additionally, a patient advisory committee composed of adults living with IBD was engaged throughout the research program, contributing to the refinement of research objectives, providing input on study activities, and advising on the interpretation of findings. Their involvement strengthened the development of a program aligned with the preferences and needs of adults with IBD. Recognizing the importance of evaluating the

feasibility of novel interventions, both to optimize allocation of research resources and to refine critical elements of subsequent trials,²⁹ the final phase of this thesis fulfills this objective by providing a methodology that was deemed feasible with specific modifications. The findings of this study contribute to the development of clearer guidance and an improved understanding of potential challenges, thereby supporting clinicians in advising patients on strategies to increase PA, whether through structured programs or alternative approaches suited to individual circumstances.

A limitation of this thesis is that the intervention was informed by a literature base that is methodologically heterogeneous, which complicated the derivation of precise dosage recommendations, i.e., frequency, intensity, type and time. Consequently, this may affect how evidence-informed the program can be at this stage. Additionally, the behaviour change strategies that were incorporated in the study intervention were informed by the perspectives of a sub-set of adults with IBD (adults 20 – 45 years old with quiescent IBD). These age range is relevant because different age groups experience IBD differently, e.g., adolescents have worries like delayed growth whereas polypharmacy is a concern unique to older adults. Consequently, strategies that may be relevant to other demographics might have been missed, potentially limiting the generalizability of the intervention's applicability.

Another limitation is the low sample size recruited in the pilot study, which made it challenging to assess the effects of the PA intervention on IBD symptoms and HRQoL, and to detect meaningful clinical differences; although that was not the purpose of the study. Furthermore, feasibility was tested in a nonrandomized pilot study. We achieved 40% recruitment, which highlights that a longer time period will be needed for recruitment in future

studies. Additionally, the program was designed and tested for adults aged 20–45 with quiescent or mildly active IBD. Findings may not be applicable to older adults, adolescents, or those with moderate to severe disease. Despite these limitations, the outcome of this research program fills critical gaps in research on PA as an adjunctive therapy for individuals with IBD.

Implications for Practice, Future Research and Health Policy

Implications for Practice:

The findings of this thesis underscore the potential role of structured, personalized PA programs as adjunctive therapy for adults with quiescent or mildly active IBD. The patient partners and clinicians consulted in this study ensured that the knowledge generated in the systematic review and qualitative studies was not only academically rigorous but also clinically meaningful and experience-aligned. Future PA guidelines and adjunct therapy recommendations for IBD should be co-developed with patients and clinicians to ensure they reflect lived experience, clinical constraints, and practical feasibility. This co-production reduces the know-do gap by generating knowledge that is immediately usable. Clinicians should consider integrating PA guidance into routine care, emphasizing personalization and behavior change strategies to address barriers such as persistent symptoms, lack of knowledge, and limited access to supportive environments. Telehealth platforms, such as LyfeMD, offer a practical avenue for delivering these interventions, promoting accessibility and engagement. User feedback during the feasibility assessment of this research program can directly influence the practical applications of telehealth delivery of programs. Usability improvements such as simplified layouts, clear language, and interactive features, are essential in this program to optimize patient experience and adherence. Iterative refinement of digital health interventions should rely heavily

on patient usability feedback and clinician safety oversight. This dual input increases acceptability, adherence, and long-term sustainability. Lastly, incorporating patient voices in program design remains critical to ensure interventions are relevant, acceptable, and sustainable.

Implications for Future Research:

Future studies should prioritize large-scale RCTs to evaluate the clinical effectiveness of IBD-specific PA interventions on symptom management, clinical outcomes, HRQoL, and disease progression. Multi-centre RCTs are recommended to maximize research resources while enhancing sample size. Research should also explore long-term adherence and sustainability of PA behaviors beyond short feasibility windows. Expanding the scope of interventions to include older adults, adolescents, and individuals with moderate to severe disease activity will enhance generalizability of study findings. Additionally, comparative studies assessing different delivery modalities, e.g., app-based versus in-person programs, could inform best practices for implementation. Furthermore, refining evidence on optimal PA dosage and dose escalation for IBD populations is necessary to strengthen clinical recommendations. Finally, economic evaluations and implementation science approaches will be valuable to assess cost-effectiveness and scalability within diverse healthcare systems.

Implications for Health Policy:

Availability of clinical guidelines on PA specifically for those with IBD would equip healthcare professionals with an evidence-informed framework for recommending PA to individuals with IBD. Policymakers should allocate funding and research efforts into the creation of clear, accessible PA guidelines unique to individuals living with IBD addressing frequency, intensity, type and duration of recommended activities. From a health equity perspective, policy

efforts must also extend beyond individual-level recommendations to address structural conditions that enable or constrain PA participation. This includes investing in safe, inclusive, and accessible public spaces that account for IBD-specific needs, such as reliable access to clean and private bathroom facilities in parks and recreation areas, climate-controlled indoor options for individuals managing fatigue or flare-related symptoms, and low-cost or free community-based PA programs. Policies should encourage continuing education for healthcare providers on the benefits of PA for IBD, including training on behaviour change strategies and the use of digital health tools. This will better equip professionals to counsel patients and implement PA interventions effectively. Together, investments in supportive environments and professional capacity-building can reduce structural barriers to PA and improve the feasibility of implementing PA recommendations for individuals living with IBD.

Conclusions

Available PA programs for the IBD population are heterogenous. Using a mixed methods design comprised of a systematic review and a qualitative description study facilitated the design of a PA program based on existing research that is patient-centred, and desired by end users. This thesis resulted in the development of an IBD-specific PA program with a focus on IBD-related symptoms and patient-preferences. I hope that with the availability of this program, heterogeneity in trials can potentially reduce. It is important to note that this program primarily applies to adults with quiescent IBD who are within the 20 – 45-year age bracket. Despite this, it provides a foundation to develop evidence-informed, patient-centred programs for all age groups with IBD, as well as contributes to the development of PA recommendations for the IBD population. By addressing both knowledge gaps and patient preferences, the ‘Active for IBD’

program represents a step toward improving HRQoL and supporting self-management in adults with IBD. Future research should focus on rigorous trials to evaluate clinical effectiveness, expand applicability to diverse age groups and disease severities, and refine digital delivery for optimal engagement.

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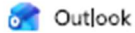
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APPENDIX I

Approval – Inclusion of Systematic Review Publication in Thesis



RE: Adding publication to thesis

From PAUL SINCLAIR <[redacted]>

Date Fri 2025-04-25 3:12 PM

To Banke Oketola [redacted]

Caution! This message was sent from outside the University of Manitoba.

Hi Banke,

For sure, you can include the SR. JCAG publishes with a CC license that allows you to use the publication, or parts thereof, as long as you reference the JCAG paper 😊

Cheers,

Paul Sinclair, MSc., CAGF

President, INSINC Consulting Inc.

Member, Board of Directors, Brightshores Health System

Managing Editor, *Journal of the Canadian Association of Gastroenterology*

Secretariat, International Working Group for the Classification of Oesophagitis



From: [redacted]

Sent: [redacted]

To: PAUL

Subject: [redacted]

Hello,

My name is Banke, a PhD candidate at the University of Manitoba.

As part of my thesis research, I worked on a systematic review. We were fortunate to have this review accepted for publication by the JCAG in 2023.

I am currently writing my thesis dissertation and I need to include this systematic review in my thesis, as it answers the first research question of my research program.

I am reaching out to confirm I am permitted to add this publication to the thesis dissertation. Kindly advise.

Thank you,
Banke

Banke Oketola, PhD Candidate

APPENDIX II

Advances in Rehabilitation Science - Posting to an institutional repository (Gold Open Access)

Permissions

Posting to an institutional repository (Gold Open Access)

Gold Open Access: Creative Commons-licensed journal articles deposited in institutional repositories

Information for authors

Authors of articles published with a Creative Commons license may arrange for the articles to be posted on the author's institutional repository immediately upon its acceptance to a Sage journal.

For information about specific funding agency Open Access policies and ensuring compliance of agency-funded articles, please see our [Funding bodies, policies and compliance](#) page.

Information for users of the institutional repository

Users who access an article in a repository may use the article in any manner consistent with the terms of the Creative Commons license attached to the article. For more information on the terms of use and summary of the Creative Commons licenses, please see our [Reusing Open Access and Sage Choice content](#) page.

Information for

Authors

Editors

APPENDIX III

INTERVIEW SCRIPT (For Qualitative Study - Chapters 3 and 4)

Opening: “Hello, thank you so much for making time to contribute to this research study.

[Response]. To give you a bit of background, we are planning to develop a physical activity program for those with Crohn’s disease or ulcerative colitis (IBD). We know that due to symptoms, there might be challenges or apprehensions to performing exercises. Thus, we are hoping to get the perspective of those with IBD, on the specific challenges and, and possible ways of overcoming those challenges. The information we get from this research will help us design the physical activity program, not only based on findings from previous research, but more importantly, based on the lived experiences of those who will use the program”.

Purpose of interview: “I will be asking you questions related to your personal experience with physical activity and exercise. We want to know how much of it you are able to do, what prevents you from being more active, performing more exercises or participating in sports, what helps you, things like that. I will be asking your opinions, so there are no right or wrong answers.”

Importance of interview: “I am hoping that the information you share with me today, though may not directly benefit you, will assist us in the design of user-friendly physical activity tools that can help manage symptoms and improve quality of life of those with IBD.”

Timeline: “This interview should take approximately forty-five minutes to an hour. Hope that is okay by you?” [Response] ‘Thank you’.

Body:

Starting with past and current participation in physical activities:

“To give some background about what I mean by physical activity, it refers to every form of muscle movement you perform throughout the day. This can include walking, taking the stairs, or participating in structured exercises or sports, either in a gym, at home or outdoors, to increase strength, muscle tone, and cardiovascular endurance” [Response].

1. What do you think of individuals with IBD performing physical activity?
 - a. What do you think people with IBD may want to gain by being more physically active?
2. Can you tell me about your experiences with performing physical activities as an individual living with IBD?
 - a. What has helped you be more physically active in the past?
 - b. What has prevented you from being physically active in the past?
2. How has your level of physical activity changed since your IBD diagnosis?
 - a. If decreased, what factors led to this decrease? (Interviewer prompts with suggestions like fatigue, fear of exacerbation of symptoms, time constraints, etc.)
 - b. If increased or maintained, what factors helped you maintain or increase your physical activity participation?
 - c. What have you heard or read about physical activity while living with IBD?

Transition - Physical, emotional and social factors that may influence engagement in physical activity:

1. “What are some of the factors that have helped you be more physically active when you wanted to be?”

Interviewer follows up with:

- a. Tell me about some of the **social** factors that help you be more physically active when you want to be?” Interviewer may prompt with, “By social factors, I mean things like supports from family and friends, financial aspects, etc.”

- b. “Can you tell me about some of the emotional factors that influence your being physically active?” Interviewer may prompt with, “By emotional factors I mean factors that might motivate you or factors that might discourage you”
 - c. “What about physical environment factors that influence your ability to be more physically active?” Interviewer may prompt with, “Physical factors are things like access to a gym for example or having weights at home.”
 - d. How do your symptoms influence your ability to be physically active?
Interviewer may prompt with, “Symptoms such as fatigue, joint pain, bowel urgency, bowel frequency.”
 - e. What strategies do you use to manage symptoms so that you can continue to be physically active?
3. We might have touched on this already, but can you tell me some of the factors or circumstances that make it difficult for you to be physically active?

Transition - Factors that may encourage target behaviour, and factors that may promote and maintain engagement and adherence:

- 4. What would encourage or help you be more physically active? Interviewer prompts with:
 - a. More information?
 - b. Supervised physical activity program, whether in-person or online?
 - c. Physical activity recommendation by your gastroenterologist, or family doctor?
- 5. If there was a group involving other individuals with IBD who were also participating in physical activity programs, would this be beneficial for you to encourage your participation in a physical activity program?
 - a. Do you think you would prefer to do physical activities/exercise on your own instead of with a group?
- 6. What do you think of the idea of designing a physical activity program **specifically** for people with IBD who are not in a flare up?
 - a. How would the availability of such a program improve your participation in physical activities?
 - b. What would be your preferred location of such a program (home, gym, outdoors)?
 - c. What would be your preferred time of day to participate in such a program?

- d. How would you like to participate in such a program – group sessions, individual sessions, supervised sessions?
 - e. What would you hope to gain from such a program?
7. If you were to receive information about how to become more physically active, how would you want to get it? Interviewer prompts with:
- i. On TV
 - ii. via email
 - iii. On a website
 - iv. From your doctor
 - v. From posters in clinics and infusion centres.
 - vi. Crohn's and Colitis Canada – Manitoba Chapter

Transition – Eliciting beliefs, capabilities and preferences:

- 8. What would make it easier for you to continue with a program/routine that increases your physical activity once you've started one?
 - a. Would you find reminders or prompts via smartwatches helpful?
 - b. Would it be helpful to be able to monitor your progress, for example on an activity tracker or online portal, to encourage you to continue to participate in physical activity?
- 9. Would you prefer seeing a physical activity professional such as a physiotherapist, kinesiologist, etc. for a physical activity prescription or you will be fine with using online resources like a YouTube video or an exercise app such as FitOn?
 - a. How would your choice influence whether you start or maintain your physical activity routine?
- 10. Do you believe you are able to engage in a sustained physical activity routine as an individual living with IBD?
 - a. If yes, why do you believe so?
 - b. If no, why not?
- 11. Is there anything else you would like to add?

Closing:

“This has been very helpful. I appreciate the time you have dedicated to complete this interview. I thank you very much for giving us an opportunity to know all these things about you. And I hope the physical activity program we develop will be of benefit to you and others living with IBD. Thank you again”

[Response]

Bye.

APPENDIX IV

Informed Consent Form – Study 2
For the Qualitative Study reported in Chapters 3 and 4
(Version Number: 01; Version Date: 23-November-2022)

RESEARCH PARTICIPANT INFORMATION AND CONSENT FORM Individual Interview

Title of Study: “Physical Activity for Individuals with Quiescent Inflammatory Bowel Diseases (IBD)”

Principal Investigator: Dr. Harminder Singh
805F-JBRC, 715 McDermot Avenue,
Winnipeg, Manitoba, Canada R3E 3P4

Co-Principal Investigator: Dr. Sandra Webber
R106-771 McDermot,
Rehabilitation Sciences Building

Co-Investigator: Banke Oketola
815A-JBRC, 715 McDermot Avenue,
Winnipeg, Manitoba, Canada R3E 3P4

Funder:

You are being asked to participate in a research study involving an individual interview. Please take your time to review this consent form and discuss any questions you may have with the study staff, your friends, or family before you make your decision. This consent form may contain words that you do not understand. Please ask the study staff to explain any words or information that you do not clearly understand.

Purpose of this Study

Some individuals with inflammatory bowel diseases (IBD) continue to have symptoms even when they are not in a flare. Physical activity and exercise may be helpful to relieve some of these persistent symptoms and improve quality of life. However, research has shown that individuals with inactive inflammatory bowel diseases do not participate in sufficient levels of physical activity. It will be helpful to know the barriers to participating in physical activity and exercise by individuals with inactive IBD. This research is being conducted to explore the experiences of physical activity by individuals with inactive IBD. We also want to identify the factors that limit or encourage participation in physical activity.

Participants Selection

You are being asked to participate in this study because you have been diagnosed with either Crohn's disease or ulcerative colitis, and you are between 20 – 45 years of age. And even though you are currently not in a flare, you are still experiencing some persistent symptoms.

A total of 20 participants will be asked to participate in this study.

Study procedures

The method of data collection for this study will be individual interviews. Individual interviews are ways of finding out people's thoughts and ideas about a specific topic. You will be asked to participate in a virtual video interview, and you will be asked to complete a demographic questionnaire. The demographic questionnaire will be used to provide your individual characteristic such as your age range, gender and IBD diagnosis. Then you will have the interview. At the interview, you will be asked questions relating to your experience with performing any form of physical activity when you are not in a flare. These questions will help us to better understand the challenges with performing physical activity by individuals with inactive IBD.

The interview will be conducted by the co-investigator. No other person will be present for the interview. Your participation in this study will involve a one-time virtual interview. This interview will take approximately 45 minutes – 1 hour. The virtual interview session will be recorded. The video recordings will be typed by the co-investigator and used to prepare a report called transcript. This is to ensure accurate reporting of the information that you provide. Personal information such as names will not be requested during the interviews. However, should any names be revealed during the interview, we will remove them from the final report.

The video recordings will be stored on a password-protected computer until the transcript is complete. We will type the report and verify its accuracy within three days after the interview. Once this is completed, the video recording will be permanently deleted. Only the transcript will be stored. The transcripts will be destroyed five years after the completion of the study.

The study will not involve follow-up at a later date. A one-page summary of the study will be provided to all participants at the end of the study via email or mail.

Risks and Discomforts

There are no anticipated physical risks to participants. However, it is possible that talking about the barriers and challenges you have experienced with physical activity may be upsetting or emotional. You do not have to answer any question that makes you feel uncomfortable or that you find too upsetting.

Benefits

Participating in this study may not help you directly, but information gained may help other people or family members with IBD in the future.

Costs

There is no cost to you to attend the individual interview. You will be able to access the questionnaire and join the virtual interview with your smart phone, tablet or computer. However, there are time-related costs. You will be required to devote approximately 1 and half hours to this study.

Payment for participation

You will be given a \$20 honorarium upon completion of your participation in this study.

Confidentiality

We will do everything possible to keep your personal information confidential. Your name will not be used at all in the study records. A list of names and email addresses of participants will be kept in a secure file so we can send you a summary of the results of the study. If the results of this study are presented in a meeting, or published, nobody will be able to tell that you were in the study. Please note that although you will not be identified as the speaker, your words may be used to highlight a specific point. The collection and access to personal information will be in compliance with provincial and federal privacy legislations.

Recording of the interview will be typed and used to prepare a report (transcript). The recording will be kept only until transcription and accuracy of the transcripts are confirmed. The typed notes will be kept for five years in a password-protected computer. Only the research staff will have access to them and know your name.

Some people or groups may need to check the study records to make sure all the information is correct. All these people have a professional responsibility to protect your privacy.

These people or groups are:

- The Health Research Ethics Board of the University of Manitoba which is responsible for the protection of people in research and has reviewed this study for ethical acceptability
- Quality assurance staff of the University of Manitoba who ensure the study is being conducted properly.
- Duly authorized members of the research team.

If any of your research records need to be copied to any of the above, your name and all identifying information will be removed. No information revealing any personal information such as your name, address or telephone number will leave the University of Manitoba.

As a participant in this study, you will be assigned a study identification number which will be used to store your data (demographic information and transcript) throughout the study. The interview will be conducted via Zoom. The video call via Zoom will be encrypted to minimise the possibility of occurrence of breach of privacy. This will be achieved by enabling end-to-end encryption. Access to the Zoom calls will be via passwords only and the Zoom call will be locked once the session commences. Recorded interviews will be stored, only until data accuracy in the transcripts is confirmed after which, recorded interviews will be permanently deleted. Your transcript will be saved only by the assigned study identification number.

A master list linking the assigned study code with your name will be maintained. It will be password-protected and stored electronically on a password-protected computer, accessible only to authorized research staff. You will complete your informed consent form and questionnaire via University of Manitoba's REDCap which is PHIA compliant and has a suite of features that ensures privacy of stored data. The informed consent forms will be removed from REDCap immediately after the consent process is completed. The electronic consent forms will be stored on a password-protected computer, separate from the master list, and will not be stored with any identifying or potentially identifying information. The data we collect will not be transmitted to any institution.

All records will be kept in a locked secure area and only those persons identified will have access to these records.

Permission to Quote:

We may wish to quote your words directly in reports and publications resulting from this. With regards to being quoted, please check yes or no for each of the following statements:

Researchers may publish documents that contain quotations by me under the following conditions:	
☐ Yes ☐ No	I agree to be quoted directly (my name is used).
☐ Yes ☐ No	I agree to be quoted directly if my name is not published (I remain anonymous).
☐ Yes ☐ No	I agree to be quoted directly if a made-up name (pseudonym) is used.

Voluntary Participation/Withdrawal from the Study

Your decision to take part in this study is voluntary. You may refuse to participate or you may withdraw from the study at any time.

Your decision not to participate or to withdraw from the study will not affect your care (or services received) at the Health Sciences Centre.

Questions

If any questions come up during or after the study contact the principal investigator and the study staff:

Dr. Harminder Singh at person@emailaddress.ca or [telephone number]

Banke Oketola at person@emailaddress.ca or [telephone number]

For questions about your rights as a research participant, you may contact The University of Manitoba, Bannatyne Campus Research Ethics Board Office at (204) 789-3389.

Consent Signatures:

1. I have read all 5 pages of the consent form.
2. I have had a chance to ask questions and have received satisfactory answers to all of my questions.
3. I understand that by signing this consent form I have not waived any of my legal rights as a participant in this study.
4. I understand that my records, which may include identifying information, may be reviewed by the research staff working with the Principal Investigator and the agencies and organizations listed in the Confidentiality section of this document.
5. I understand that I may withdraw from the study at any time and my data may be withdrawn prior to publication.
6. I understand I will be provided with a copy of the consent form for my records.
7. I agree to participate in the study.

Participant signature _____ **Date** _____
(day/month/year)

Participant printed name: _____

I, the undersigned, have fully explained the relevant details of this research study to the participant named above and believe that the participant has understood and has knowingly given their consent

Printed Name: _____ **Date** _____
(day/month/year)

Signature: _____

Role in the study: _____

APPENDIX V

Informed Consent Form – Study 3
For the Feasibility Study reported in Chapter 5
(Version Number: 03; Version Date: 15-May-2025)

RESEARCH PARTICIPANT INFORMATION AND CONSENT FORM

Title of Study: Physical Activity for Individuals with Quiescent or Mildly active Inflammatory Bowel Diseases (IBD).

Principal Investigator: Dr. Harminder Singh
805F-JBRC, 715 McDermot Avenue,
Winnipeg, Manitoba, Canada R3E 3P4

Co-Principal Investigator: Dr. Sandra Webber
R120-771 McDermot Avenue,
Rehabilitation Sciences Building

Co-Investigator: Banke Oketola
815A-JBRC, 715 McDermot Avenue,
Winnipeg, Manitoba, Canada R3E 3P4

Funder:

You are being asked to participate in a research study. Please take your time to review this consent form and discuss any questions you may have with the study staff. You may take your time to make your decision about participating in this study and you may discuss it with your friends, family or your doctor before you make your decision. This consent form may contain words that you do not understand. Please ask the study staff to explain any words or information that you do not clearly understand.

Purpose of Study

Some individuals with inflammatory bowel diseases (IBD), specifically Crohn's disease and Ulcerative Colitis, continue to have symptoms even when they are not in a flare. Physical activity and exercise may be helpful to relieve some of these persistent symptoms and improve quality of life. However, research has shown that individuals with inactive or mildly active IBD often do not participate in sufficient levels of physical activity. We have developed a behaviour change physical activity program specifically for adults living with IBD who continue to experience persistent symptoms. This program comprises of modifications to facilitate performing more physical activity thereby changing behaviour towards physical activity.

Knowledge on physical activity and IBD are also incorporated into this program, in addition to personalized physical activities and exercises that will be performed during study participation. This research is being conducted to determine if this program can help adults living with IBD be more physically active. We also want to find out if by performing physical activity and exercise via this program, there can be improvements in persistent symptoms.

A total of 15 adults with IBD will participate in this study.

Study procedures

If you take part in this study, you will be asked to complete five (5) study visits:

1. One (1) in-person baseline visit at the University of Manitoba/Health Sciences Centre. This visit will take approximately 2 hours. At this visit, you will:
 - a. Complete three questionnaires.
 - b. Perform goal-setting activities with a research staff to develop personal physical activity goals.
 - c. Be given a Garmin Vivosmart 5 fitness tracker which will be worn daily during study participation.
2. Four (4) follow up visits at week 1, week 4, week 8 and week 12. These visits will be completed via Zoom, and will take approximately 40 minutes. At these visits, you will:
 - a. Complete questionnaires (or you may complete these prior to the visit).
 - b. Perform goal-setting activities to be achieved in the next four weeks.
 - c. Be given access to the physical activity app loaded with your personalized physical activity plan. This physical activity plan will be updated every four weeks as you progress throughout the study.

As part of the intervention, the physical activity app also includes functions to help you change your behaviour to perform more physical activity so you can meet your personal and study physical activity goals. We will collect your weekly physical activity data from the online account set up for the Garmin Vivosmart fitness tracker. At the last visit (week 12), in addition to the regular study activities, we will also complete a social validity questionnaire. The purpose of the questionnaire is to share your acceptability of the physical activity program. In total, you will be asked to dedicate 6.5 hours for research visits, at least 5 hours/week for three months for physical activity participation, and 4 months of fitness tracking.

Participation in the study will be for 12 weeks. Follow up at 16 weeks will involve collecting physical activity data from the Garmin Vivosmart 5 account only to see your physical activity in the last month when you were not receiving new information from the study.

The researcher may decide to remove you from this study if new information becomes available that shows participating is no longer in your best interest. You can also stop participating at any time. However, if you decide to stop participating in the study, we encourage you to talk to the study staff first. There are no consequences to withdrawing from the study.

A one-page summary of the study results will be provided to all participants at the end of the study via email or mail.

Description of Study visits					
	Baseline visit	Week 1	Week 4	Week 8	Week 12
Consent	x				
Demographic and clinical information questionnaire	x				
COM questionnaire	x				X
Questionnaire - Disease activity	x				X
Questionnaires – IBD symptoms and quality of life		x	x	x	X
Goal setting activities	x	x	x	x	
Review of physical activity goals			x	x	X
Fitness tracker and account set-up	x				
Physical activity app set-up		x			
Upload personalized physical activity/exercises to app		x	x	x	
Review of adverse events			x	x	X
Social Validity questionnaire					X

Risks and Discomforts

There are no anticipated physical risks to participants. However, you may experience muscle soreness when you perform activities and exercises you have not performed before. Complaints of dizziness, light-headedness and nausea while performing physical activity and exercise have also been reported by individuals with IBD (~ 2%). You will be given education on how to look out for activities that can trigger such reactions, and how to manage them during your participation in the study. Your IBD condition may not improve or may worsen while participating in this study.

Benefits

There may or may not be direct benefit to you from participating in this study. We hope the information learned from this study will benefit other people with Crohn's disease or Ulcerative Colitis in the future.

Costs

All the procedures which will be performed as part of this study, are provided at no cost to you. You may incur transportation and/or parking costs to attend the in-person baseline visit. Other tools you will use in this study (fitness tracker and physical activity app) will be given at no cost to you.

Payment for participation

You will be given a \$20 honorarium for the baseline visit and \$10 honorarium for each completed follow up study visit to a maximum of \$60 upon termination of your participation in this research study.

Alternatives

You do not have to participate in this study to receive treatment for your condition. Please talk to your gastroenterologist about all your treatment options.

Confidentiality

During your participation in this study, the researcher and research team will collect and store information about you. They will only collect information necessary for the study. Information gathered in this research study may be published or presented in public forums, however your name and other identifying information will not be used or revealed. Despite efforts to keep your personal information confidential, absolute confidentiality cannot be guaranteed. Your personal information may be disclosed if required by law.

We have safeguards in place, both physical and electronic, to protect the privacy and security of personal information. As a participant in this study, you will be assigned a study identification number which will be used to store your data throughout the study. Information that will be collected include your age, date of birth, height, weight, contact information, past and present state of health, disease severity, physical activity in moderate and vigorous zones, heart rate, and sleep data. All your study data will be stored using your assigned study identification number, not your name or anything that can potentially identify you. Physical records will be stored in locked cabinets in a locked, secure office with access restricted to study team members only. Electronic records will be stored on secure drives accessible only by password-protected computers. Physical documents containing identifying information about you (e.g., this informed consent form) will be stored in a locked cabinet separate from your other physical study records. Questionnaires will be collected and stored using the University of Manitoba's REDCap which is PHIA compliant and has a suite of features that ensures privacy of stored data.

The virtual visits will be conducted via Zoom. The video call via Zoom will be encrypted to minimise the possibility of occurrence of breach of privacy. This will be achieved by enabling end-to-end encryption. Access to the Zoom calls will be via passwords only and the Zoom call will be locked once the session commences.

The physical activity app will not be used to collect any data, it will only be used to deliver the physical activity program. Your study identification number will be used to create your account on the app, not your name, email address or any other personal information that can potentially identify you. The app has a chat feature that participants can use to communicate with each other for the purpose of providing social support. We strongly advise against sharing any personal information on the chat. We will collect your physical activity data from the online account of the Garmin Vivosmart 5. A study-specific email address will be created and assigned to you. This will be used to create the online account, not your personal email address. Your study identification number will be used to identify you on the fitness tracker account and the physical activity app. Please note that the tracker has the capability to track your geographical locations. You are **not** required to activate this feature to participate in this study. If you decide to activate this feature, your location details will not be collected in this research study. All your data collected through the fitness tracker is viewed by Garmin as belonging to you, the Garmin wearer, and not Garmin. They do not access any data collected via the fitness tracker except through your consent or required to by law. This policy can be viewed here: <https://www.garmin.com/en-US/privacy/global/>

A master list linking the assigned study identification number with your name will be maintained. It will be password-protected and stored electronically on a password-protected computer, accessible only to authorized research staff. The data we collect will not be transmitted to any institution.

People or organizations may inspect and/or copy your research records for quality assurance purposes or data analysis. All these people have a professional responsibility to protect your privacy.

These people or groups are:

- The Health Research Ethics Board of the University of Manitoba which is responsible for the protection of people in research and has reviewed this study for ethical acceptability.
- Quality assurance staff of the University of Manitoba who ensure the study is being conducted properly.
- Duly authorized members of the research team.

All records will be kept in a locked secure area and only those persons identified will have access to these records. If any of your research records need to be copied to any of the above, your name and all identifying information will be removed. No information revealing any

personal information such as your name, address or telephone number will leave the University of Manitoba.

Voluntary Participation/Withdrawal from the Study

Your decision to take part in this study is voluntary. You may refuse to participate or you may withdraw from the study at any time. Your decision not to participate or to withdraw from the study will not affect your care at this centre. If the study staff feel that it is in your best interest to withdraw you from the study, they will remove you without your consent.

We will tell you about any new information that may affect your health, welfare, or willingness to stay in this study.

Medical Care for Injury Related to the Study

You are not waiving any of your legal rights by signing this consent form nor releasing the investigator(s) from their legal and professional responsibilities.

Questions

You are free to ask any questions that you may have about your participation and your rights as a research participant. If any questions come up during or after the study or if you have a research-related injury, contact the study doctor and the study staff:

Dr. Harminder Singh at person@emailaddress.ca or [telephone number]

Dr. Sandra Webber at person@emailaddress.ca or [telephone number]

Banke Oketola at person@emailaddress.ca or [telephone number]

For questions about your rights as a research participant, you may contact The University of Manitoba, Bannatyne Campus Research Ethics Board Office at (204) 789-3389.

Do not sign this consent form unless you have had a chance to ask questions and have received satisfactory answers to all of your questions.

Statement of Consent

I have read this consent form. I have had the opportunity to discuss this research study with Dr. Singh, Dr. Webber and their study staff. I have had my questions answered by them in a language I understand. The risks and benefits have been explained to me. I believe that I have not been unduly influenced by any study team member to participate in the research study by any statements or implied statements. Any relationship (such as employer, supervisor or family member) I may have with the study team has not affected my decision to participate. I understand that I will be given a copy of this consent form after signing it. I understand that my participation in this study is voluntary and that I may choose to withdraw at any time. I freely agree to participate in this research study.

I understand that information regarding my personal identity will be kept confidential, but that confidentiality is not guaranteed. I authorize the inspection of any of my records that relate to this study by The University of Manitoba Research Ethics Board for quality assurance purposes.

By signing this consent form, I have not waived any of the legal rights that I have as a participant in a research study.

I agree to be contacted for future follow-up in relation to this study,

Yes ☐ No ☐

Participant signature: _____

Date _____

(day/month/year)

Participant printed name: _____

I, the undersigned, have fully explained the relevant details of this research study to the participant named above and believe that the participant has understood and has knowingly given their consent.

Printed Name: _____

Date _____

(day/month/year)

Signature: _____

Role in the study: _____

APPENDIX VI

Active for IBD Intervention - Knowledge component

Education

*Each line item will be put into an infographic or poster, which will be disseminated via the app.

*Interval of delivery: 3/week (Total of 36 for the entire study duration for each participant).

S/N	Details
	IBD
1.	<u>Cause of IBD</u> Research suggests genetics and environment interact with the gut bacteria and contribute to the onset of IBD. People of any age can get IBD, but it is most commonly diagnosed in older teenagers and those in their twenties. https://www.canada.ca/en/public-health/services/chronic-diseases/inflammatory-bowel-disease.html
2.	<u>Difference between Crohn's disease and Ulcerative Colitis:</u> In Crohn's disease, the inflammation can be in any part of the digestive tract, from mouth to anus. This inflammation can occur in all the layers of the bowel wall. In Ulcerative Colitis, inflammation is in the large intestine only and occurs in the inner lining of the bowel wall.
3.	<u>Quick Fact</u> The amount of saliva you produce increases when you start experiencing nausea. This is to protect your teeth from the stomach acids when you throw up.
4.	<u>Mental Health Support</u> Most hospital-based psychology services (inpatient and outpatient) in Canada, including in Manitoba, are funded through provincial governments. This does not include private clinical psychologists. If you find you require mental health assessments, supports or services, resources may be available at no cost to you through tertiary or regional centres. Many private insurance plans also have some amount of coverage. Speak to your Gastroenterologist or GI nurse to find services closest to you. You can find more information here: www.mps.ca/find-psychologist https://www.cmhaacrossmb.ca/your-mental-health/finding-help/
5.	<u>Preparing for Colonoscopy</u> Colonoscopy is very much a part of the IBD journey. You might experience some anxiety regarding upcoming colonoscopies. To get in-depth, quality information on what to expect, how to prepare, different bowel preparation laxative options, as well as personal stories of some peoples' experiences of colonoscopy, to allay your concerns, see https://mycolonoscopy.ca/
6.	<u>Crohn's and Colitis Canada</u> The Crohn's and Colitis Canada is a rich resource for information on IBD. You can get information on a wide variety of topics ranging from navigating the IBD journey, medications, vaccines and contributing to research. For more information: https://crohnsandcolitis.ca
7.	<u>Living with IBD</u> There can be ups and downs with living with IBD, and people have different experiences. With effective treatment, it is possible to live with IBD with little to no interference on quality of life. Many people go on to function well at school, work, and in the family. A 2015 Manitoba research study found that children with IBD and children without IBD have similar

	achievements in grade 12. https://www.sciencedirect.com/science/article/abs/pii/S0022347614011597
8.	<u>Accommodations when living with IBD</u> Depending on your symptoms and experiences of living with IBD, you may require accommodations at work or school. You can request accommodations such as: • Frequent short breaks instead of one long break. • Workstation close to a bathroom. • Hybrid work arrangement or flexible work arrangement to make time for medical appointments. • Self-determined timing of tasks and breaks. Flexibility with work start times. Students can obtain doctor's notes with which they can request accommodations regarding bathroom access during class or exams through the Accessibility Centre of the school or institution. https://www.ibdmanitoba.org/new-diagnosis-of-ibd/
9	<u>Reduced Mobility during active IBD</u> IBD flares can lead to long time periods sitting or lying down. Spending so much time not moving around much, can lead to: • general decrease in muscle mass. • increase production of cytokines (a type of protein) that causes inflammation. • less excitability of neurons, which can result in muscle weakness. • reduced bone strength. • less muscle endurance and aerobic capacity. Performing as much physical activities as you can tolerate as soon as possible can reduce the impact of immobilization. 'Use it or lose it'.
10	<u>Vaccinations</u> IBD and medications to treat IBD can affect the immune system. Therefore, it is important for those living with IBD be up to date with their vaccines. https://crohnsandcolitis.ca
11	<u>Traveling with IBD</u> Living with IBD should not prevent you from travelling. For tips on how to prepare for your trips and travels, please see: https://crohnsandcolitis.ca/About-Crohn-s-Colitis/IBD-Journey/Travel-and-Lifestyle
12	<u>Community Engagement</u> As an individual living with Crohn's disease or Ulcerative colitis, you can make an impact in the lives of others living with IBD. There are several opportunities for engagement such as participating in research, raising awareness, fundraising events, etc. For more information on ways to engage, please visit: https://crohnsandcolitis.ca/Get-Involved
PHYSICAL ACTIVITY	
1.	<u>Ongoing symptoms with Inactive IBD</u> When IBD is no longer active (i.e., no flare), some people continue to have persistent symptoms. Research suggests that engaging in a regular physical activity routine, including exercises of mild and moderate intensities, as well as resistance training may decrease some of these persistent symptoms and improve quality of life. *Highlight* Performing physical activity and exercise is considered safe for individuals living with IBD. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9991245/
2.	<u>World Health Organization (WHO) Physical Activity Recommendation</u>

	Some physical activity is better than no physical activity at all. Essentially, all physical activity counts, including household tasks, taking the stairs, and walking in the mall. https://www.who.int/europe/publications/i/item/9789240014886
3.	<u>Canadian 24-hr Movement Guidelines</u> The Canadian 24-hour Movement Guidelines provide recommendations for sleep, physical activity and sedentary time within a 24-hour period. Specifically, • Get 7-9 hours of good quality sleep, keeping sleep and wake-up times similar every day. • Interrupt prolonged sitting and replace it with several hours of light physical activities such as standing, slow walking, household tasks, etc., throughout the day. • Perform moderate to vigorous activities and accumulate at least 150 minutes per week. • Incorporate muscle strengthening activities involving major muscle groups such as the upper arm, thigh muscles, glutes, core, chest and shoulders, at least twice a week. *Can use the CSEP infographic here instead. https://csepguidelines.ca/
4.	<u>Components of a typical exercise session:</u> 1. Warm up: light or moderate activities, typically less than 15 minutes, performed to allow the body to gradually adjust to the demands of the exercise session. 2. Exercise session: can be aerobic exercises like cycling; resistance training such as squats; and/or flexibility exercises such as Yoga. This can last from 10 – 60 minutes depending on your goals, fitness level and intensity of the exercises. 3. Cool down: Activities done in this phase allow the body to return as close to resting levels as possible. Typically lasts about 5-10 minutes and activities can include stretching and slow walking.
5.	<u>IBD and Osteoporosis</u> Osteoporosis, reduced bone mineral density, is commonly found in individuals living with IBD. This can increase the risk of fractures. Resistance exercises, such as bicep curls and squats, target your muscles and bones, and have been found to promote increase in lean muscle mass and bone mineral density. Individuals with IBD are encouraged to include resistance training in their physical activity routine to counteract the effects of IBD and IBD medications. https://canadianibdtoday.com/article/view/2-1-targownik_et_al
6.	<u>The Gut Microbiome</u> The collection of microbes and their genes in the gut are referred to as the gut microbiome. An abnormality in the composition of the microbes is believed to result in the dysregulation which causes inflammation seen in IBD. Research suggests that the gut microbiome can respond to environmental factors such as regular physical activity and exercise, altering its composition and increasing microbial diversity, which is beneficial in IBD. https://www.ibdmanitoba.org/gut-microbiome
7.	<u>Exercise Volume</u> Your 'Exercise Volume' is the total amount of exercise you perform that result in health and fitness benefits. This is the dose response relationship. Your Exercise Volume is a combination of the frequency (F), the intensity (I) and the duration (T) of your exercise sessions. E.g., 15 minutes (duration) of brisk walking (moderate intensity), three times per week (frequency). To continue to gain benefits of physical activity and exercise, it is important to gradually increase your dose, that is, your exercise volume.

	https://professionals.wrha.mb.ca/old/professionals/primary-care-providers/files/physical-activity-essentials-handout.pdf
8.	CSEP poster – combination of PA, sleep and sedentary time within the day.
9.	<u>Potential side effects of Physical Activity/Exercise</u> In a recent review of research publications on physical activity among those with IBD, very few side effects of physical activity/exercises were identified. These include complaints of dizziness, nausea, and light-headedness (9 out of 174 people) and increased IBD activity (7 out of 174 people). Also, it is normal and very common to experience muscle soreness when you participate in physical activity and exercise that is unfamiliar to you. To avoid some of these effects, it is important to: • hydrate properly throughout the physical activity session • wear light comfortable clothing • ensure your environment is well ventilated • perform warm up and cool down activities • perform gentle stretches when experiencing muscle soreness. https://academic.oup.com/jcag/article/6/5/162/7240614?login=false
10.	<u>Walking</u> If walking your main form of physical activity, you can challenge yourself by walking briskly or carrying weights while walking. Of note, weights do not have to be expensive. You can simply carry a can of soup in each hand. Need to challenge yourself even more? Carry milk jugs instead!
11.	<u>Low Motivation?</u> You might not always feel ready to tackle your physical activity goals. That's okay. Perform some gentle stretches or mobility exercises instead. If you can handle a bit more, perform self-paced walking within your living space while scrolling on your phone or taking a phone call. Any physical activity is better than no physical activity.
12.	<u>Strength Training Benefits</u> Benefits of strength training include improved functional independence, improved cognitive functioning, improved self-esteem and mood, as well as slowing the progression of osteoporosis, which is desirable when living with IBD.
BEHAVIOUR CHANGE	
1.	<u>Physical activity behaviour of most adult Canadians (infographic)</u> Performing physical activity regularly is difficult for most people. • Less than half of adult Canadians meet the recommended physical activity recommendation of 150 minutes of moderate-vigorous physical activity per week. • Only half of the people get at least 3 hours of light physical activity per day. • Most adults in Canada are sedentary for 9.6 hours per day, not including time spent sleeping. Changing behaviour to engage in physical activity regularly is challenging for most people. It is even more challenging for those living with chronic medical conditions like IBD. https://www.participation.com/
2.	<u>Physical activity behaviour change</u> Getting active can be challenging and intimidating. If you are feeling overwhelmed, that is normal! It is easier and more fun when you get active with others, including family and friends. But if you prefer to workout on your own, that can be fun too. Exercise videos can be of help. https://www.participation.com/get-active/
3.	<u>Tips to sneak some physical activity into your day:</u> • Create hourly reminders to stand up from your desk and walk for 5 – 10 minutes.

	• Perform stretches in sitting. • Incorporate sitting exercises throughout the day such as seated twists, side crunches, sitting straight-leg-raises. • Take the longer route to your destination or pick up the pace. • Make playtime with family and friends interactive, instead of activities like watching a movie. • Take a walk during meetings rather than sitting at your desk. • Keep exercise equipment handy by your desk or couch.
4.	<u>Endorphins and Exercise</u> When you get into the groove of your exercise session, your body releases endorphins. The name endorphin is derived from "endogenous" which means 'made in your body' and "morphine", a type of opioid. Essentially, endorphins are feel-good chemicals produced by your body. They are the chemicals behind the popular 'runners' high', the short-lasting euphoric state after intense exercise. Moderate intensity physical activity is one of the rockstars of releasing endorphins. Research highlights that 45 minutes of aerobic exercise three times a week can be a strong antidepressant. Be encouraged to try moderate intensity physical activities! https://onlinelibrary.wiley.com/doi/10.1002/da.22842
5.	<u>Intensity of Exercise</u> Light intensity exercises and physical activities are those activities that do not result in you becoming short of breath or sweating. Examples of light intensity activities include slow walking, playing catch, fishing, cycling (≤ 5 mph), stretching and light housework. Moderate to vigorous intensity exercises and activities are those that make you sweat, breathe more heavily, and start to feel warm. Examples include brisk walking, running, dancing, pushing a lawn mower, hiking and cycling. It is recommended that adults perform between 150-300 minutes of moderate to vigorous intensity exercises or physical activities each week. When unable to perform moderate or vigorous intensity exercises, replace with light exercises rather than not performing any at all.
6.	<u>Physical activity while living with IBD</u> Research suggests that light and moderate intensity exercises are safe for adults living with Crohn's disease or Ulcerative colitis. Individuals living with IBD are encouraged to participate in up to 30 minutes of moderate intensity exercise 3-5 times per week, plus resistance training 2 – 3 times per week to improve bone mineral density and maintain strength. You are encouraged to listen to your body and avoid exercises that worsen any persistent symptoms. https://crohnsandcolitis.ca/About-Crohn-s-Colitis/IBD-Journey/Exercise-and-Lifestyle/Therapeutic-Monitoring#recommendations-for-people-with-ibd
7.	<u>Coping Strategies</u> Maintaining a routine of consistent physical activity is challenging for most people and even more for those living with IBD. However, we have learnt that with appropriate coping strategies, adults living with IBD can maintain a consistent physical activity routine. Some coping strategies include: • Map out the location of bathrooms in gyms, parks and community centres where exercise will be performed. The Crohn's and Colitis Canada developed the GoHere Washroom Access Program which is a free app which can be used to easily find bathrooms near you. https://crohnsandcolitis.ca/Support-for-You/GoHere-Washroom-Access • Pre-plan your walking or running route in your neighbourhood so you are not too far from home or a friend's house for easy bathroom access.

	- Identify barriers specific to you and create coping strategies to manage them. - Set easy and manageable physical activity goals and then build on them when they become easy for you to perform. E.g., walk for 10 minutes at lunch break 3 days a week. You can then build on this by increasing it to 20 minutes of walking or 15 minutes of brisk walking. Make your goals SMART (Specific, Measurable, Achievable, Realistic and Time-bound). - Reward your successes and achievements.
8.	<u>Barriers to physical activity engagement for adults with IBD</u> - IBD-related symptoms include ongoing feeling of tiredness, joint pain, stomach pain, and diarrhea. Exercises can be modified to accommodate the specific symptom. E.g., avoid high impact exercises when knee or ankle joint pain is present. - Financial constraints. Your exercise routine does not have to cost you a lot of money. On-line videos can be used for working out at home instead of going to the gym. Body weight or milk jugs can be used as weights with resistance exercises. - Unfavourable weather. - Lack of time. - Work-related tiredness: You can perform your physical activities in the mornings or incorporate them into your day, e.g. taking a 15-minute brisk walk during lunch break, seated exercises while at your desk, etc.
9.	<u>Kevin Dineen</u> Kevin is a former Canadian professional Ice Hockey player who was diagnosed with Crohn's disease in 1987. This did not prevent him from playing hundreds of games and achieving several important milestones. In 2021, he became the head coach of the Utica Comets, a professional Ice Hockey team based in Utica, New York.
10.	<u>AbbVie IBD Scholarship</u> The Crohn's and Colitis Canada's AbbVie IBD Scholarship program offers \$5000 for students attending a Canadian post-secondary institution. For more information and application requirements: https://crohnsandcolitis.ca/Support-for-You/IBD-Scholarships
11.	<u>Clinton Shard Memorial Scholarship</u> Clinton Shard was a 2012 AbbVie IBD Scholarship recipient. He was diagnosed with Crohn's disease at the age of 12 years and went on to become a passionate champion and advocate for IBD. The Clinton Shard Memorial Scholarship honours the legacy of Clinton Shard. For more information: https://crohnsandcolitis.ca/Support-for-You/IBD-Scholarships/Clinton-Shard-Memorial-Scholarship
12.	<u>Mental Health and IBD</u> The lifelong reality of living with IBD, the unpredictability of the disease and how it might impact school, work, family-life, reinforces a persistent sense of worry, stress and anxiety. High rates of anxiety and depression symptoms have been found among individuals with IBD. A recent research study found that one-third of individuals living with IBD reported a perceived need for mental health care. Ask your Gastroenterologists or healthcare provider about available supports. https://journals.lww.com/jcge/abstract/2024/05000/perceived_need_for_mental_health_care_in_a_cohort.7.aspx