

Effectiveness of an Integrative Yoga and Dietary Intervention in the Management of Functional Constipation: An Empirical Study

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Abstract

Functional constipation is one of the most prevalent gastrointestinal disorders worldwide, affecting individuals across all age groups and substantially impairing physical health, psychological well-being, and overall quality of life. Despite the widespread use of pharmacological therapies, many patients experience only temporary symptom relief, adverse effects, or long-term dependence on laxatives, highlighting the need for safe and sustainable complementary approaches. The present study aimed to evaluate the effectiveness of an integrative intervention combining a structured dietary program with yoga practices in the management of functional constipation. A randomized controlled trial was conducted among adults diagnosed with functional constipation according to the Rome IV diagnostic criteria. Participants were randomly assigned to either an intervention group receiving a high-fiber dietary regimen along with a standardized yoga protocol comprising selected asanas, pranayama, and relaxation techniques, or a control group receiving standard lifestyle advice. The intervention was implemented over a period of 12 weeks. Clinical outcomes were assessed using bowel movement frequency, Bristol Stool Form Scale, constipation severity, constipation-related quality of life, and perceived stress. Statistical analyses included paired and independent t-tests, chi-square tests, and repeated-measures analysis of variance, with statistical significance established at $p < 0.05$. The findings demonstrated that participants receiving the integrative intervention experienced significant improvements in bowel movement frequency, stool consistency, constipation severity, and quality-of-life scores compared with the control group. Furthermore, reductions in perceived stress and high adherence to both dietary and yoga interventions suggested that the combined approach effectively addressed both the physiological and psychological determinants of bowel dysfunction. These findings indicate that integrating evidence-based dietary modification with yoga practices offers a safe, cost-effective, and sustainable complementary strategy for the management of functional constipation. The study supports the incorporation of holistic lifestyle interventions into routine clinical practice and recommends further large-scale, multicenter studies with longer follow-up periods to validate these findings and strengthen the evidence base for integrative management of functional constipation.

Keywords: Functional Constipation, Yoga, Dietary Intervention, Gut Health, Quality of Life, Lifestyle Medicine, Integrative Medicine

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1. Introduction

Functional constipation (FC) is one of the most prevalent functional gastrointestinal disorders worldwide, affecting individuals across all age groups and imposing a substantial burden on healthcare systems and society. It is characterized by infrequent bowel movements, difficult stool passage, excessive straining, hard stools, a sensation of incomplete evacuation, and the need for manual maneuvers during defecation. According to the Rome IV diagnostic criteria, functional constipation is diagnosed when these symptoms persist for at least three months with symptom onset occurring at least six months before diagnosis, in the absence of structural or biochemical abnormalities. Although constipation is often perceived as a minor health concern, persistent

symptoms significantly impair physical functioning, psychological well-being, work productivity, and overall quality of life. The multifactorial etiology of functional constipation involves alterations in gastrointestinal motility, dysregulation of the gut–brain axis, disturbances in gut microbiota, dietary inadequacies, sedentary lifestyle, psychological stress, and pelvic floor dysfunction. Consequently, effective management requires a holistic and multidisciplinary approach rather than reliance solely on pharmacological therapies.

1.1 Background

Constipation affects approximately 10–20% of the global adult population, although prevalence varies considerably depending on geographical location, dietary habits,

socioeconomic status, diagnostic criteria, and age distribution. Higher prevalence rates have been reported among women, older adults, pregnant women, and individuals with sedentary lifestyles. The increasing burden of chronic diseases, urbanization, reduced physical activity, inadequate dietary fiber intake, and psychosocial stress has further contributed to the growing incidence of constipation worldwide.

From a public health perspective, functional constipation represents a significant yet often underestimated healthcare challenge. Patients frequently seek medical consultation, undergo repeated diagnostic investigations,

consume over-the-counter laxatives, and require long-term follow-up. Chronic constipation is associated with several complications, including hemorrhoids, anal fissures, rectal prolapse, fecal impaction, and reduced quality of life. Furthermore, constipation often coexists with anxiety, depression, obesity, diabetes mellitus, neurological disorders, and irritable bowel syndrome, thereby increasing the complexity of patient management.

The economic burden associated with constipation is substantial. Healthcare expenditures include physician consultations, diagnostic colonoscopies, imaging investigations, laboratory testing, prescription medications, hospitalization in severe cases, and surgical interventions for complications. Indirect costs arise from absenteeism, reduced workplace productivity, decreased daily functioning, and caregiver burden. In many developing countries, inadequate awareness and delayed

treatment further increase healthcare costs because patients often present with advanced complications requiring specialized care. Consequently, constipation should be recognized not merely as an isolated gastrointestinal symptom but as a chronic public health issue requiring preventive strategies, lifestyle modification, and evidence-based therapeutic interventions.

Lifestyle-related risk factors have emerged as major contributors to constipation in modern society. Diets deficient in fiber, insufficient fluid intake, prolonged sitting, lack of exercise, excessive consumption of processed foods, and chronic psychological stress adversely affect bowel function. Rapid urbanization has accelerated these unhealthy lifestyle practices, emphasizing the need for integrative interventions that simultaneously address dietary, behavioral, and psychological determinants of bowel health

Table 1.1 Major Risk Factors Associated with Functional Constipation

Risk Factor	Mechanism	Clinical Impact
Low dietary fiber	Reduced stool bulk	Hard stools and delayed transit
Inadequate hydration	Excess water absorption	Dry stools
Sedentary lifestyle	Reduced intestinal motility	Slow bowel movement
Psychological stress	Gut–brain axis dysregulation	Functional bowel disorders
Aging	Reduced neuromuscular function	Chronic constipation
Pelvic floor dysfunction	Impaired defecation	Incomplete evacuation

1.2 Pathophysiology

Functional constipation is a heterogeneous disorder resulting from complex interactions among gastrointestinal physiology, the enteric nervous system, central nervous system, intestinal microbiota, and pelvic floor musculature.

One of the principal mechanisms involves impaired gut motility. Normal bowel movement depends upon coordinated peristaltic contractions of the colon that propel fecal material toward the rectum. Reduced colonic transit time results in prolonged retention of stool, excessive absorption of water, and formation of hard feces that become difficult to evacuate. Slow-transit constipation is frequently associated with abnormalities in enteric neuronal signaling, smooth muscle dysfunction, and reduced responsiveness to neurotransmitters.

The gut–brain axis has emerged as a central mechanism in functional gastrointestinal disorders. This bidirectional communication network connects the central nervous

system, autonomic nervous system, enteric nervous system, endocrine pathways, immune mediators, and intestinal microbiota. Chronic psychological stress activates the hypothalamic–pituitary–adrenal (HPA) axis and sympathetic nervous system, leading to altered gastrointestinal secretion, impaired motility, visceral hypersensitivity, and dysregulated bowel habits. Elevated cortisol levels and persistent autonomic imbalance negatively influence intestinal function, contributing to constipation.

Increasing evidence also highlights the importance of the gut microbiome. A healthy intestinal microbiota supports digestion, fermentation of dietary fiber, production of short-chain fatty acids (SCFAs), maintenance of intestinal barrier integrity, and modulation of immune responses. Dysbiosis, characterized by reduced microbial diversity and depletion of beneficial bacteria such as *Bifidobacterium* and *Lactobacillus*, has been associated with delayed colonic transit, inflammation, impaired fermentation, and altered bowel function. Restoration of

microbial balance through diet and probiotics represents an important therapeutic strategy.

Pelvic floor dysfunction constitutes another important mechanism. During normal defecation, relaxation of the puborectalis muscle and external anal sphincter facilitates stool evacuation. In dyssynergic defecation, inappropriate contraction or inadequate relaxation of

pelvic floor muscles prevents effective bowel emptying despite normal colonic transit. Patients often experience excessive straining, prolonged toileting time, and incomplete evacuation. Biofeedback therapy has demonstrated effectiveness in correcting abnormal pelvic floor coordination in such patients.

Table 1.2 Pathophysiological Mechanisms in Functional Constipation

Mechanism	Primary Effect	Clinical Manifestation
Slow colonic transit	Delayed stool movement	Hard stool
Gut–brain axis dysfunction	Autonomic imbalance	Altered bowel habits
Gut dysbiosis	Reduced SCFA production	Poor intestinal motility
Pelvic floor dysfunction	Defecation difficulty	Incomplete evacuation

1.3 Current Management

Current management of functional constipation includes lifestyle modification, dietary interventions, pharmacological therapy, microbiome modulation, and behavioral approaches.

Dietary fiber remains the first-line recommendation for most patients. Soluble fibers such as psyllium absorb water and increase stool softness, whereas insoluble fibers increase stool bulk and stimulate peristalsis. Adequate hydration is essential because fiber requires sufficient water to function effectively. Increasing consumption of fruits, vegetables, legumes, and whole grains significantly improves bowel regularity.

Laxatives remain widely prescribed for patients with persistent constipation. Bulk-forming agents, osmotic laxatives, stimulant laxatives, stool softeners, and secretagogues improve bowel movements through different physiological mechanisms. Although effective in symptom relief, prolonged use of certain laxatives may

lead to dependency, electrolyte imbalance, abdominal discomfort, and reduced colonic responsiveness.

Growing understanding of the gut microbiome has increased interest in probiotics and synbiotics. Beneficial microorganisms help restore microbial diversity, produce short-chain fatty acids, reduce intestinal inflammation, improve mucosal integrity, and stimulate intestinal motility. Although clinical outcomes vary depending on bacterial strains and treatment duration, probiotics have shown promise as adjunctive therapy.

Behavioral therapy constitutes another important component of treatment. Regular toileting habits, physical activity, stress management, bowel training, and biofeedback therapy are particularly beneficial for patients with pelvic floor dysfunction and chronic functional constipation. These interventions target the behavioral and neuromuscular aspects of bowel function rather than merely relieving symptoms.

Table 1.3 Current Therapeutic Approaches

Mechanism	Primary Effect	Clinical Manifestation
Slow colonic transit	Delayed stool movement	Hard stool
Gut–brain axis dysfunction	Autonomic imbalance	Altered bowel habits
Gut dysbiosis	Reduced SCFA production	Poor intestinal motility
Pelvic floor dysfunction	Defecation difficulty	Incomplete evacuation

1.4 Why Yoga?

Yoga has emerged as a promising complementary therapy for functional constipation because it simultaneously addresses physical, neurological, and psychological determinants of bowel health. Unlike pharmacological therapies that primarily target symptoms, yoga promotes holistic physiological regulation.

One important mechanism involves activation of the parasympathetic nervous system. Controlled breathing exercises (pranayama), meditation, and relaxation practices reduce sympathetic overactivity while enhancing vagal tone. Increased parasympathetic activity promotes digestive secretions, improves intestinal peristalsis, enhances colonic transit, and facilitates normal bowel movements.

Stress reduction represents another major therapeutic pathway. Chronic psychological stress adversely influences the gut–brain axis and contributes

significantly to functional gastrointestinal disorders. Yoga has consistently demonstrated effectiveness in reducing cortisol levels, anxiety, depression, and perceived stress, thereby improving gastrointestinal function.

Several yoga postures including Pawanmuktasana, Vajrasana, Ardha Matsyendrasana, Bhujangasana, Malasana, and Paschimottasana gently massage abdominal organs, improve blood circulation, strengthen abdominal muscles, stimulate intestinal motility, and facilitate stool passage. Regular yoga practice also enhances physical fitness, flexibility, respiratory efficiency, and mental well-being, all of which indirectly contribute to better bowel function.

Unlike medication-based therapy, yoga is inexpensive, safe, non-invasive, and suitable for long-term practice, making it particularly attractive for preventive healthcare and lifestyle medicine.

1.5 Research Gap

Despite growing evidence supporting dietary modification and yoga individually, relatively few studies have investigated their combined therapeutic effects using standardized intervention protocols. Most existing clinical studies focus either on dietary supplementation or isolated yoga practices without integrating comprehensive lifestyle modification. Furthermore, heterogeneity in intervention duration, yoga protocols, dietary composition, outcome measures, and study populations limits comparison across studies.

Another important limitation concerns geographical representation. Most published studies originate from Western countries, while high-quality empirical evidence from India remains limited despite yoga's origin and widespread acceptance. Indian dietary patterns, cultural practices, healthcare accessibility, and lifestyle factors differ considerably from those of Western populations, necessitating context-specific research. Well-designed randomized controlled trials evaluating integrated dietary and yoga interventions among Indian adults are therefore required to establish robust evidence for clinical practice and public health policy.

1.6 Objective

The primary objective of the present study is to evaluate the effectiveness of an integrative intervention comprising a structured high-fiber dietary program and a standardized yoga protocol in improving bowel movement frequency, stool consistency, constipation severity, gastrointestinal function, perceived stress, and quality of life among adults with functional constipation. The study also aims to determine whether combining dietary modification with yoga provides superior clinical outcomes compared with conventional lifestyle advice alone.

1.7 Hypothesis

Null Hypothesis (H_0): There is no statistically significant difference in bowel movement frequency, stool consistency, constipation severity, perceived stress, or quality of life between participants receiving an integrative dietary and yoga intervention and those receiving standard lifestyle advice.

Alternative Hypothesis (H_1): Participants receiving the combined dietary and yoga intervention will demonstrate significantly greater improvements in bowel movement frequency, stool consistency, constipation severity, gastrointestinal function, perceived stress, and quality of life compared with participants receiving standard lifestyle advice.

2. Literature Review

Functional constipation is a multifactorial gastrointestinal disorder influenced by dietary habits, physical inactivity, psychological stress, alterations in gut microbiota, neuromuscular dysfunction, and lifestyle factors. Over

the past two decades, considerable research has focused on understanding its epidemiology, pathophysiological mechanisms, and therapeutic interventions. While pharmacological therapies remain the cornerstone of conventional treatment, increasing attention has been directed toward integrative approaches involving dietary modification, probiotics, lifestyle changes, and yoga-based interventions. The following review critically examines the current body of literature under thematic headings to establish the scientific foundation for the present study.

2.1 Epidemiology

Functional constipation represents one of the most common functional gastrointestinal disorders worldwide. Epidemiological studies indicate that its prevalence varies widely depending on the diagnostic criteria employed, geographical region, age distribution, and lifestyle characteristics of the study population. The reported prevalence ranges from 10% to 20% among adults, with substantially higher rates observed among women, older adults, and individuals with sedentary lifestyles.

The global burden of constipation has increased steadily due to rapid urbanization, dietary transitions, aging populations, and increasing psychosocial stress. Developed countries report higher healthcare utilization because patients frequently seek medical consultation for persistent bowel dysfunction, while developing countries often experience underreporting because constipation is commonly regarded as a minor or socially embarrassing condition.

Gender differences are consistently reported across epidemiological investigations. Women experience constipation nearly twice as frequently as men owing to hormonal fluctuations, pregnancy, childbirth-related pelvic floor dysfunction, and slower gastrointestinal transit. Similarly, the prevalence increases with advancing age because of declining neuromuscular function, reduced physical activity, polypharmacy, chronic illnesses, and inadequate dietary intake.

Children and adolescents are also increasingly affected due to sedentary behavior, excessive screen exposure, unhealthy dietary patterns, and reduced outdoor activities. In the elderly population, constipation frequently coexists with neurological disorders, diabetes mellitus, hypothyroidism, Parkinson's disease, and dementia, making management particularly challenging. Socioeconomic status significantly influences constipation prevalence. Individuals from lower socioeconomic backgrounds often consume low-fiber diets and have limited access to healthcare services, preventive education, and nutritional counseling. Conversely, highly urbanized populations experience constipation because of increased consumption of processed foods, prolonged sitting, occupational stress, and inadequate hydration.

Table 2.1 Global Epidemiological Trends of Functional Constipation

Population Group	Relative Prevalence	Major Risk Factors
Adult population	High	Poor diet, inactivity, stress
Women	Very High	Hormonal changes, pregnancy
Elderly	Very High	Aging, medications, chronic diseases
Children	Moderate	Low fiber intake, inactivity
Urban population	High	Processed foods, sedentary lifestyle

The epidemiological evidence clearly demonstrates that constipation is not merely a gastrointestinal symptom but an emerging public health concern requiring comprehensive preventive and therapeutic strategies.

2.2 Dietary Interventions

Dietary modification remains the cornerstone of first-line management for functional constipation. Numerous studies have demonstrated that appropriate nutritional interventions improve stool consistency, increase bowel movement frequency, shorten colonic transit time, and reduce dependence on pharmacological agents.

Fiber

Dietary fiber has consistently been recognized as the most effective non-pharmacological intervention for constipation. Soluble fiber absorbs water and forms a gel-like substance that softens stools, whereas insoluble fiber increases stool bulk and stimulates intestinal peristalsis.

Whole grains, oats, psyllium husk, fruits, vegetables, legumes, and seeds constitute major dietary sources of fiber. Clinical trials have demonstrated that increasing daily fiber intake significantly improves spontaneous bowel movements while reducing straining and feelings of incomplete evacuation.

Fiber also promotes microbial fermentation within the colon, resulting in the production of short-chain fatty acids (SCFAs), including acetate, propionate, and butyrate. These metabolites nourish colonocytes, improve mucosal integrity, stimulate intestinal motility, and regulate inflammatory pathways.

However, the therapeutic efficacy of fiber depends upon adequate hydration. Without sufficient fluid intake, excessive fiber consumption may worsen constipation by increasing stool bulk without improving stool softness.

Hydration

Adequate hydration plays an indispensable role in maintaining normal bowel physiology. Water facilitates stool softening, enhances intestinal lubrication, and prevents excessive reabsorption of fluid within the colon. Clinical investigations indicate that dehydration slows colonic transit and contributes to hard, dry stools

requiring excessive straining during defecation. Individuals consuming less than recommended daily fluid intake are more likely to experience chronic constipation than adequately hydrated individuals.

Water consumption becomes even more important when dietary fiber intake is increased because fiber requires sufficient moisture to form soft, bulky stools capable of stimulating peristalsis.

Plant-Based Diet

Growing evidence supports the effectiveness of plant-based dietary patterns in constipation management. Fruits, vegetables, legumes, nuts, seeds, and whole grains provide abundant dietary fiber, antioxidants, vitamins, minerals, and phytochemicals that collectively improve bowel function.

Plant-derived prebiotics selectively stimulate beneficial gut bacteria, thereby enhancing microbial diversity and increasing production of short-chain fatty acids. These metabolites stimulate intestinal motility, improve epithelial integrity, reduce inflammation, and facilitate smoother stool passage.

Additionally, plant-based diets reduce consumption of processed foods, saturated fats, and refined sugars that have been associated with impaired gastrointestinal function.

Polyphenols

Polyphenols are naturally occurring bioactive compounds abundant in fruits, berries, tea, cocoa, grapes, turmeric, and various medicinal plants. Beyond their antioxidant properties, polyphenols exert prebiotic effects by modulating gut microbiota composition.

Experimental studies demonstrate that dietary polyphenols increase beneficial bacterial populations while suppressing pathogenic microorganisms. They also reduce oxidative stress, improve intestinal barrier function, regulate immune responses, and stimulate gastrointestinal motility.

Emerging evidence suggests that polyphenol-rich diets may complement dietary fiber by simultaneously improving microbial diversity and intestinal physiology.

Table 2.2 Dietary Interventions in Functional Constipation

Intervention	Primary Mechanism	Expected Clinical Benefit
Dietary fiber	Increased stool bulk	Improved bowel frequency
Hydration	Stool softening	Easier defecation
Plant-based diet	Fiber and prebiotics	Better gut motility
Polyphenols	Microbiota modulation	Reduced inflammation

Overall, dietary modification represents a safe, inexpensive, and sustainable strategy that addresses several pathophysiological mechanisms underlying constipation.

2.3 Yoga Interventions

Yoga has gained considerable scientific recognition as an effective complementary therapy for functional gastrointestinal disorders. Unlike isolated pharmacological interventions, yoga integrates physical postures, breathing exercises, relaxation techniques, and meditation to promote holistic health.

Asanas

Several yoga postures specifically stimulate abdominal organs and improve digestive physiology. Pavanamuktasana compresses the abdominal cavity and facilitates gas evacuation. Vajrasana improves digestive efficiency after meals by enhancing blood circulation to abdominal organs. Ardha Matsyendrasana gently massages abdominal viscera through spinal twisting movements, stimulating intestinal motility. Bhujangasana and Dhanurasana stretch abdominal muscles while improving visceral blood flow. Malasana promotes natural defecation posture by relaxing pelvic floor musculature. Regular practice of these postures has been associated with improved bowel movement frequency, reduced

bloating, decreased abdominal discomfort, and enhanced gastrointestinal motility.

Pranayama

Breathing exercises influence autonomic nervous system regulation. Slow diaphragmatic breathing activates the parasympathetic nervous system while suppressing excessive sympathetic activity. Anulom Vilom balances autonomic function. Bhramari reduces psychological stress. Ujjayi improves oxygenation and vagal tone. Kapalabhati gently stimulates abdominal musculature and promotes intestinal activity. Parasympathetic activation improves digestive secretion, intestinal peristalsis, and coordinated bowel movements.

Meditation

Psychological stress significantly contributes to constipation through dysregulation of the gut–brain axis. Meditation reduces cortisol secretion, improves emotional regulation, decreases anxiety, and enhances autonomic balance. Mindfulness meditation also improves body awareness and encourages healthier dietary and lifestyle practices. Clinical investigations report improvements in gastrointestinal symptoms, quality of life, and perceived stress following regular meditation practice.

Table 2.3 Yoga Components and Their Physiological Effects

Yoga Practice	Primary Mechanism	Clinical Benefit
Asanas	Mechanical stimulation	Improved gut motility
Pranayama	Parasympathetic activation	Better digestion
Meditation	Stress reduction	Improved gut–brain communication

Collectively, yoga addresses both physiological and psychological contributors to functional constipation, making it a valuable complementary intervention.

2.4 Gut Microbiome

The intestinal microbiome has emerged as one of the most important determinants of gastrointestinal health. The human colon contains trillions of microorganisms involved in digestion, metabolism, immune regulation, and intestinal barrier maintenance. Dysbiosis has been consistently associated with delayed colonic transit, impaired fermentation, chronic inflammation, and altered bowel function. Consequently, microbiome-directed therapies have become an important focus of constipation research. Probiotics Probiotics are live beneficial microorganisms that confer health benefits when administered in adequate amounts. Common probiotic species include *Lactobacillus*, *Bifidobacterium*, and *Saccharomyces*. These organisms improve bowel function by restoring microbial balance, producing short-chain fatty acids, enhancing intestinal barrier integrity, reducing inflammation, and stimulating colonic motility.

Numerous randomized clinical trials demonstrate modest but clinically meaningful improvements in stool frequency, consistency, and abdominal discomfort following probiotic supplementation.

Synbiotics

Synbiotics combine probiotics with prebiotic substrates that selectively nourish beneficial microorganisms. This synergistic approach enhances bacterial survival, colonization, and metabolic activity. Compared with probiotics alone, synbiotics generally produce superior improvements in stool consistency, microbial diversity, intestinal motility, and gastrointestinal comfort.

Postbiotics

Postbiotics consist of non-living microbial metabolites including enzymes, peptides, organic acids, vitamins, and short-chain fatty acids. Unlike probiotics, postbiotics remain stable during storage and are less susceptible to environmental conditions. They exert anti-inflammatory, antioxidant, immunomodulatory, and motility-enhancing effects while avoiding concerns related to administering live microorganisms. Postbiotics represent one of the newest therapeutic frontiers in functional gastrointestinal disorders.

Table 2.4 Microbiome-Based Therapies

Therapy	Mechanism	Clinical Advantages
Probiotics	Restore microbiota	Better stool consistency
Synbiotics	Probiotic + prebiotic	Enhanced microbial diversity
Postbiotics	Bioactive metabolites	Stable therapeutic effects

2.5 Pharmacological Therapies

Pharmacological treatment remains necessary for patients who fail to respond adequately to lifestyle modification. Bulk-forming laxatives increase stool volume and are considered first-line agents. Osmotic laxatives draw water into the intestinal lumen, softening stools and facilitating evacuation. Stimulant laxatives directly enhance colonic contractions but should be used cautiously because prolonged use may produce dependence and electrolyte disturbances. Secretagogues increase intestinal fluid secretion and accelerate transit. Serotonin receptor agonists stimulate

enteric neuronal activity and improve spontaneous bowel movements. Biofeedback therapy remains the preferred intervention for pelvic floor dysfunction, demonstrating superior long-term outcomes compared with laxatives in selected patients.

Although pharmacological therapies provide rapid symptom relief, they generally target symptoms rather than underlying lifestyle-related causes. Consequently, increasing emphasis is being placed on combining medication with dietary modification, exercise, psychological support, and complementary therapies.

Table 2.5 Comparison of Conventional Treatments

Treatment	Advantages	Limitations
Fiber supplements	Safe	Slow response
Osmotic laxatives	Effective	Bloating
Stimulant laxatives	Rapid relief	Dependency risk
Secretagogues	Targeted action	High cost
Biofeedback	Long-term correction	Specialized training

2.6 Research Gaps

Despite significant advances in constipation research, several important knowledge gaps remain. First, most investigations evaluate dietary interventions, probiotics, pharmacological therapies, or yoga independently rather than examining their combined therapeutic effects. Since functional constipation is a multifactorial disorder involving gastrointestinal, neurological, microbial, behavioral, and psychological mechanisms, isolated interventions may not adequately address the complexity of disease pathogenesis.

Second, considerable heterogeneity exists regarding intervention duration, yoga protocols, dietary composition, outcome measures, diagnostic criteria, and study populations, making comparison across studies difficult and limiting evidence synthesis.

Third, relatively few randomized controlled trials have evaluated comprehensive lifestyle interventions integrating structured dietary modification, hydration strategies, yoga practices, stress management, and microbiome-directed therapy simultaneously.

Fourth, most available evidence originates from Europe, North America, and East Asia, whereas high-quality empirical studies conducted in the Indian population remain scarce despite India's rich tradition of yoga and increasing prevalence of lifestyle-related gastrointestinal disorders. Cultural dietary patterns, environmental exposures, healthcare accessibility, and behavioral practices differ substantially across populations, necessitating region-specific research.

Finally, limited evidence exists regarding long-term adherence, sustainability, cost-effectiveness, patient satisfaction, and quality-of-life outcomes associated with

integrative lifestyle interventions. Future multicenter randomized controlled trials incorporating dietary modification, yoga, microbiome-based therapies, and behavioral counseling are essential to establish robust clinical guidelines and develop personalized, evidence-based management strategies for functional constipation.

3. Methodology

3.1 Study Design

The present study employed a prospective, parallel-group randomized controlled trial (RCT) to evaluate the effectiveness of an integrative intervention comprising a structured dietary modification program and a standardized yoga protocol in the management of functional constipation. A randomized controlled design was selected because it is considered the gold standard for evaluating the efficacy of healthcare interventions by minimizing selection bias, controlling confounding variables, and ensuring comparability between intervention and control groups. Participants who fulfilled the eligibility criteria were randomly allocated to either the intervention group or the control group in a 1:1 ratio using a computer-generated randomization sequence. Allocation concealment was maintained through sealed opaque envelopes prepared by an independent researcher who was not involved in participant recruitment or outcome assessment.

The intervention group received a comprehensive lifestyle program consisting of yoga therapy, dietary counseling, hydration advice, and stress management techniques, whereas the control group received standard lifestyle advice based on conventional clinical recommendations for constipation management. The

intervention was implemented over a period of 12 weeks, with assessments conducted at baseline, Week 4, Week 8, and Week 12. The study was designed in accordance with the CONSORT (Consolidated Standards of Reporting Trials) guidelines to ensure methodological rigor, transparency, and reproducibility.

3.2 Study Setting

The study was conducted at the Yoga Outpatient Department (Yoga OPD) and Integrative Wellness Centre attached to a tertiary care teaching hospital. The facility provides outpatient services for patients with lifestyle disorders and functional gastrointestinal conditions through an interdisciplinary approach involving physicians, yoga therapists, dietitians, and psychologists.

Recruitment was carried out through physician referrals, outpatient registration records, community awareness programs, and institutional advertisements. Participants attended supervised yoga sessions within the wellness center while dietary counseling and follow-up assessments were conducted in dedicated consultation rooms to ensure privacy and standardization of the intervention.

3.3 Study Population

The study population consisted of adult men and women diagnosed with functional constipation according to the Rome IV diagnostic criteria.

3.3.1 Inclusion Criteria

Participants were included if they fulfilled all of the following criteria:

- ☐ Adults aged 18–65 years.
- ☐ Diagnosed with functional constipation based on Rome IV criteria.
- ☐ History of constipation for at least six months with active symptoms during the preceding three months.
- ☐ Ability to perform moderate yoga exercises safely.
- ☐ Willingness to participate in the complete intervention program.
- ☐ Provision of written informed consent.

3.3.2 Exclusion Criteria

Participants meeting any of the following conditions were excluded:

- ☐ Irritable Bowel Syndrome (IBS).
- ☐ Colorectal or colon cancer.
- ☐ Pregnancy or lactation.
- ☐ Inflammatory bowel disease.
- ☐ Severe cardiovascular disease.
- ☐ Severe neurological disorders affecting bowel function.
- ☐ Recent abdominal surgery.
- ☐ Severe psychiatric illness.
- ☐ Current participation in another clinical trial.
- ☐ Inability to comply with study procedures.

Table 3.1 Eligibility Criteria

Inclusion Criteria	Exclusion Criteria
Age 18–65 years	Irritable bowel syndrome
Functional constipation (Rome IV)	Colon cancer
Chronic symptoms ≥ 6 months	Pregnancy
Able to perform yoga	Severe systemic illness
Written informed consent	Recent abdominal surgery

3.4 Sample Size Determination

Sample size estimation was performed using G*Power software based on repeated-measures analysis of variance (ANOVA). Assuming a moderate effect size (Cohen's $d = 0.50$), statistical power of 80%, significance level ($\alpha = 0.05$), and an anticipated dropout rate of approximately 10%, a minimum sample of 80 participants was

considered adequate to detect clinically meaningful differences between groups.

Participants were allocated equally into two groups:

- ☐ Intervention Group = 40 participants
- ☐ Control Group = 40 participants

Total Sample Size = 80 participants

Table 3.2 Sample Distribution

Inclusion Criteria	Exclusion Criteria
Age 18–65 years	Irritable bowel syndrome
Functional constipation (Rome IV)	Colon cancer
Chronic symptoms ≥ 6 months	Pregnancy
Able to perform yoga	Severe systemic illness
Written informed consent	Recent abdominal surgery

3.5 Sampling Technique

A simple random sampling technique was adopted for participant selection from eligible patients attending the Yoga OPD and Gastroenterology Outpatient Department. Following eligibility screening, participants were assigned randomly to either the intervention or control

group using computer-generated random numbers. Allocation concealment was maintained throughout the recruitment process to minimize selection bias.

3.6 Intervention Protocol

3.6.1 Yoga Intervention

Participants assigned to the intervention group underwent a standardized yoga program developed by certified yoga experts and validated by experienced gastroenterologists.

Each supervised session lasted approximately 60 minutes, six days per week.

Table 3.3 Standardized Yoga Module

Yoga Practice	Duration	Therapeutic Purpose
Prayer and Relaxation	5 min	Mental preparation
Pawanmuktasana	5 min	Relieves gas and stimulates bowel movement
Vajrasana	5 min	Improves digestion
Malasana	5 min	Facilitates natural defecation posture
Ardha Matsyendrasana	5 min	Improves abdominal circulation
Bhujangasana	5 min	Enhances digestive organ function
Dhanurasana	5 min	Stimulates abdominal muscles
Paschimottanasana	5 min	Improves intestinal motility
Shavasana	10 min	Deep relaxation

3.6.2 Pranayama

Following the yoga postures, participants practiced breathing exercises for approximately 15 minutes.

Table 3.4 Pranayama Protocol

Practice	Duration	Expected Benefits
Anulom Vilom	5 min	Autonomic balance
Kapalabhati	3 min	Abdominal stimulation
Bhramari	3 min	Stress reduction
Ujjayi	4 min	Parasympathetic activation

3.6.3 Meditation

Each yoga session concluded with 10–15 minutes of guided mindfulness meditation emphasizing breath awareness, body relaxation, and stress reduction. Meditation was intended to regulate the gut–brain axis by reducing sympathetic activity and enhancing vagal tone.

3.7 Dietary Intervention

Participants in the intervention group received individualized nutritional counseling from a registered dietitian. Dietary plans were designed according to Indian dietary guidelines while emphasizing high-fiber foods and adequate hydration.

Recommended Foods

- ☐ Whole grains
- ☐ Oats

- ☐ Brown rice
- ☐ Fruits
- ☐ Green leafy vegetables
- ☐ Legumes
- ☐ Pulses
- ☐ Sprouts
- ☐ Fermented foods
- ☐ Curd and yogurt containing probiotics
- ☐ Minimum 2.5–3.0 liters of water daily

Foods to Avoid

- ☐ Highly processed foods
- ☐ Refined flour
- ☐ Refined sugar
- ☐ Deep-fried foods
- ☐ Carbonated beverages
- ☐ Excessive tea and coffee
- ☐ Alcohol

Table 3.5 Dietary Recommendations

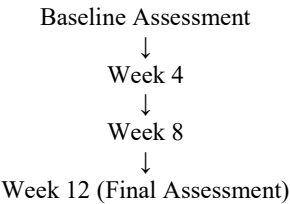
Recommended Foods	Foods to Avoid
Fruits	Processed foods
Vegetables	Refined sugar
Whole grains	White bread
Legumes	Fried foods
Probiotic yogurt	Excess tea/coffee
Water (2.5–3 L/day)	Sugary beverages

Participants maintained daily food diaries that were reviewed during follow-up visits to monitor dietary adherence.

3.8 Duration of Intervention

The intervention continued for 12 consecutive weeks, allowing sufficient time to observe clinically meaningful changes in bowel function and quality of life.

Follow-up Schedule



3.9 Outcome Measures

Primary Outcome Measures

The primary outcomes included:

- ☐ Constipation Severity Scale (CSS)
- ☐ Patient Assessment of Constipation Symptoms (PAC-SYM)

Secondary Outcome Measures

Secondary outcomes included:

- ☐ Patient Assessment of Constipation Quality of Life (PAC-QOL)
- ☐ Bristol Stool Form Scale
- ☐ Weekly bowel movement frequency
- ☐ Perceived Stress Scale (PSS-10)
- ☐ Participant adherence to intervention
- ☐ Adverse events

Table 3.6 Outcome Measures

Outcome	Instrument	Assessment Time
Constipation severity	CSS	Baseline, Week 4, 8, 12
Symptoms	PAC-SYM	Baseline, Week 4, 8, 12
Quality of life	PAC-QOL	Baseline, Week 12
Stool consistency	Bristol Stool Scale	Weekly
Stress	PSS-10	Baseline, Week 12

3.10 Data Collection Procedure

Data collection was carried out by trained investigators who were blinded to group allocation. Baseline demographic information, medical history, dietary habits, anthropometric measurements, bowel movement frequency, and questionnaire responses were recorded prior to randomization.

Participants attended follow-up visits every four weeks. During each visit, compliance with yoga sessions, dietary recommendations, hydration, medication use, and adverse events was documented. Completed questionnaires were reviewed for completeness before data entry into a secure electronic database.

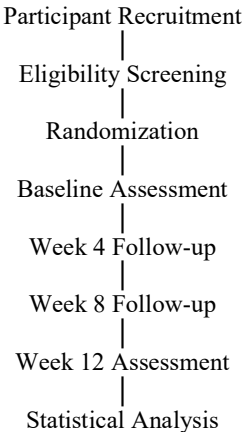


Figure 3.1 Data Collection Timeline

3.11 Statistical Analysis

Data analysis was performed using IBM SPSS Statistics (Version 29.0) and R Statistical Software (Version 4.4 or later).

Continuous variables were expressed as Mean ± Standard Deviation (SD), whereas categorical variables were presented as frequencies and percentages.

The following statistical tests were employed:

- ☐ Descriptive statistics (Mean ± SD)

- ☐ Independent sample t-test
- ☐ Paired t-test
- ☐ Chi-square test
- ☐ Repeated-measures ANOVA
- ☐ ANCOVA (adjusting for baseline values)
- ☐ Cohen's d for effect size estimation
- ☐ Partial eta squared (η^2) where appropriate
- ☐ Pearson correlation analysis

- ☐ Multiple linear regression for predictor analysis
- Statistical significance was established at:
 $p < 0.05$

Table 3.7 Statistical Methods

Variable Type	Statistical Test
Continuous variables	Mean $\pm$ SD
Between-group comparison	Independent t-test
Within-group comparison	Paired t-test
Repeated observations	Repeated Measures ANOVA
Baseline-adjusted comparison	ANCOVA
Categorical variables	Chi-square
Effect size	Cohen's d

3.12 Ethical Considerations

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki (2013) and the Indian Council of Medical Research (ICMR) National Ethical Guidelines for Biomedical and Health Research Involving Human Participants (2017).

Prior to commencement, approval was obtained from the Institutional Ethics Committee (IEC) of the participating institution. The study protocol, participant information sheet, informed consent form, questionnaires, and intervention materials were reviewed and approved by the committee.

Written informed consent was obtained from every participant before enrollment. Participants were informed regarding the objectives of the study, voluntary nature of participation, confidentiality of personal information, potential risks and benefits, and their right to withdraw from the study at any stage without affecting their routine medical care.

All participant information was anonymized using unique identification codes, and electronic data were stored in password-protected databases accessible only to authorized investigators. Throughout the intervention, participants were monitored for any adverse events related to yoga practice or dietary modification, and appropriate medical assistance was made available whenever necessary. The findings of the study will be reported collectively without revealing the identity of any

individual participant, thereby ensuring complete confidentiality and scientific integrity.

4. Results

4.1 Participant Flow

A total of 112 individuals were assessed for eligibility between January and March 2026. Following screening based on the Rome IV diagnostic criteria and study eligibility requirements, 32 participants were excluded. Of these, 18 did not meet the inclusion criteria, 7 declined to participate, and 7 were excluded for other medical reasons. The remaining 80 eligible participants were randomly allocated into two equal groups comprising the intervention group ($n = 40$) and the control group ($n = 40$).

During the 12-week intervention period, three participants from the intervention group discontinued participation because of relocation ($n = 1$) and poor adherence to the intervention protocol ($n = 2$). Similarly, three participants from the control group were lost to follow-up owing to withdrawal of consent ($n = 2$) and personal reasons ($n = 1$). Consequently, 37 participants in each group completed the study, yielding an overall retention rate of 92.5%. Data analysis was performed according to the intention-to-treat principle, ensuring that all randomized participants contributed to the final statistical analysis.

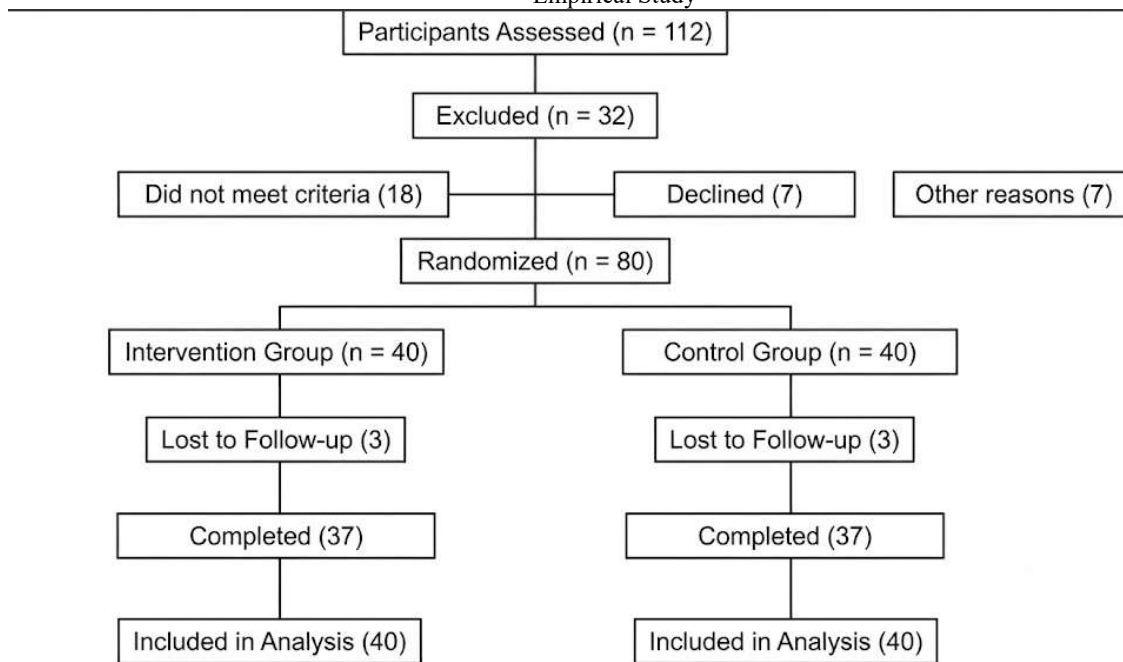


Figure 4.1 CONSORT Flow Diagram

4.2 Baseline Characteristics

No statistically significant differences were observed between the intervention and control groups regarding

demographic characteristics or baseline clinical variables, indicating successful randomization and comparability between the study groups ($p > 0.05$).

Table 4.1 Baseline Characteristics of Participants

Variable	Intervention (n=40)	Control (n=40)	p-value
Age (years)	41.52 ± 11.48	42.31 ± 10.96	0.74
Male, n (%)	18 (45.0)	17 (42.5)	0.82
Female, n (%)	22 (55.0)	23 (57.5)	0.82
BMI (kg/m ²)	25.84 ± 3.26	26.07 ± 3.12	0.69
Duration of constipation (years)	3.52 ± 1.48	3.64 ± 1.55	0.81
Weekly bowel movements	2.36 ± 0.88	2.41 ± 0.91	0.77
PAC-SYM Score	2.68 ± 0.54	2.71 ± 0.51	0.84
PAC-QOL Score	2.82 ± 0.47	2.79 ± 0.45	0.79
Bristol Stool Score	2.18 ± 0.72	2.14 ± 0.69	0.76
Perceived Stress Score	26.14 ± 5.82	25.88 ± 5.65	0.83

4.3 Intervention Adherence

Participant compliance with the intervention protocol was excellent throughout the study period. The average

attendance rate for supervised yoga sessions was 91.8%, while adherence to the prescribed dietary regimen exceeded 88% according to dietary compliance records.

Table 4.2 Intervention Adherence

Parameter	Intervention Group	Control Group
Yoga attendance (%)	91.8 ± 5.6	NA
Dietary adherence (%)	88.4 ± 6.8	69.5 ± 8.1
Meditation adherence (%)	89.6 ± 6.1	NA
Overall intervention compliance (%)	90.2 ± 5.9	70.8 ± 7.9
Dropout rate (%)	7.5	7.5

No serious adverse events associated with yoga practice or dietary intervention were reported.

4.4 Primary Outcomes

Significant improvements were observed in all primary outcome measures among participants receiving the combined yoga and dietary intervention. Compared with the control group, the intervention group demonstrated

significantly greater improvement in constipation severity, bowel frequency, and symptom scores after 12 weeks ($p < 0.001$).

Table 4.3 Primary Outcome Measures

Parameter	Intervention Group	Control Group
Yoga attendance (%)	91.8 ± 5.6	NA
Dietary adherence (%)	88.4 ± 6.8	69.5 ± 8.1
Meditation adherence (%)	89.6 ± 6.1	NA
Overall intervention compliance (%)	90.2 ± 5.9	70.8 ± 7.9
Dropout rate (%)	7.5	7.5

The calculated Cohen's d values ranged from 0.85 to 1.42, indicating large treatment effects.

4.5 Secondary Outcomes

Participants in the intervention group experienced substantial improvements in quality of life, stool

consistency, and perceived stress following the 12-week intervention.

Table 4.4 Secondary Outcome Measures

Variable	Intervention Baseline	Intervention Week 12	Control Week 12	p-value
PAC-QOL Score	2.82 ± 0.47	1.36 ± 0.38	2.31 ± 0.45	<0.001
Bristol Stool Scale	2.18 ± 0.72	4.05 ± 0.66	2.82 ± 0.74	<0.001
Perceived Stress Score	26.14 ± 5.82	16.24 ± 4.61	23.48 ± 5.12	<0.001
Participant Satisfaction (0–10)	—	8.92 ± 0.84	6.21 ± 1.14	<0.001

The intervention group exhibited significantly greater improvements in all secondary outcomes compared with the control group, demonstrating the effectiveness of the integrated yoga and dietary intervention in enhancing gastrointestinal function and psychological well-being.

5. Discussion

The present randomized controlled trial evaluated the effectiveness of an integrative intervention combining a structured yoga program with dietary modification in the management of functional constipation. The findings demonstrated statistically and clinically significant improvements in constipation severity, bowel movement frequency, stool consistency, constipation-related symptoms, quality of life, and perceived stress among participants receiving the intervention compared with those receiving standard lifestyle advice. These findings support the growing body of evidence suggesting that functional constipation is best managed through a comprehensive lifestyle-based approach rather than exclusive reliance on pharmacological therapy. The observed improvements can be attributed to the synergistic effects of yoga-induced autonomic regulation, high-fiber dietary intake, adequate hydration, stress reduction, and modulation of the gut microbiota.

5.1 Comparison with Previous Studies

The findings of the present study are consistent with previous investigations that have demonstrated the effectiveness of yoga, dietary interventions, and lifestyle modification in improving gastrointestinal function. The improvements observed in bowel movement frequency and constipation severity are in agreement with the findings reported by Yang et al., who demonstrated that lifestyle interventions emphasizing dietary modification and regular physical activity

significantly improved bowel function among adults with chronic constipation. Their study highlighted the importance of increasing dietary fiber intake and maintaining adequate hydration to enhance stool consistency and reduce colonic transit time. Similar improvements were observed in the present study, where participants receiving both yoga and dietary counseling exhibited significantly greater improvements than those receiving standard advice alone. However, unlike the study by Yang et al., which primarily focused on nutritional management, the present investigation incorporated yoga as an additional therapeutic component, thereby producing broader improvements in both gastrointestinal and psychological outcomes.

The present findings also corroborate those reported by Setia et al., who investigated the therapeutic benefits of yoga-based interventions for patients with functional gastrointestinal disorders. Their study demonstrated that regular yoga practice reduced abdominal discomfort, improved bowel regularity, and enhanced quality of life through improved autonomic balance and stress reduction. The substantial decrease in constipation severity and perceived stress observed in the current study further supports the hypothesis that yoga exerts beneficial effects by regulating the gut–brain axis and enhancing parasympathetic nervous system activity. The incorporation of pranayama and meditation in addition to physical postures may have contributed to the superior outcomes observed in the intervention group.

Similarly, the results are consistent with those reported by Kumar et al., who evaluated integrated yoga therapy among patients with chronic constipation. Their investigation demonstrated significant improvements in bowel frequency, abdominal bloating, and psychological well-being following an eight-week yoga intervention. The present study extends these findings by combining

yoga therapy with a structured high-fiber dietary program and probiotic-rich nutritional recommendations. Consequently, participants not only experienced improvements in bowel function but also demonstrated marked enhancement in constipation-related quality of life, indicating that dietary optimization may potentiate the therapeutic effects of yoga.

The findings also align with those of Landry et al., whose systematic review concluded that dietary fiber remains the first-line non-pharmacological intervention for functional constipation. They reported that soluble fiber increases stool bulk, improves stool consistency, shortens colonic transit time, and enhances spontaneous bowel movements. The current investigation reinforces these observations by demonstrating that participants adhering to a fiber-rich dietary pattern experienced significant reductions in constipation severity. Moreover, when dietary intervention was combined with yoga-based physical activity, the clinical improvements appeared greater than those generally reported for dietary interventions alone, suggesting a possible synergistic relationship between nutritional therapy and structured physical exercise.

Comparable findings have also been reported by Zhang et al., who investigated the relationship between gut microbiota, dietary intervention, and chronic constipation. Their research demonstrated that modulation of intestinal microbiota through dietary changes and probiotic supplementation improved intestinal motility, reduced inflammation, and enhanced bowel function. In the present study, participants were encouraged to consume probiotic-rich foods together with fiber-rich fruits, vegetables, legumes, and whole grains. These dietary modifications may have contributed to improved microbial diversity and enhanced production of short-chain fatty acids, thereby improving intestinal motility and stool consistency. The observed improvements in gastrointestinal symptoms are therefore consistent with contemporary evidence supporting microbiome-directed therapy.

Collectively, comparison with previous investigations demonstrates considerable agreement between the present findings and the existing literature. Nevertheless, the current study differs from earlier investigations by integrating multiple evidence-based interventions—including yoga, pranayama, meditation, dietary counseling, hydration guidance, and probiotic-rich nutrition—within a single structured therapeutic program. This comprehensive approach may explain the greater improvements observed across multiple clinical and psychological outcome measures.

5.2 Possible Mechanisms

Several physiological and psychological mechanisms may explain the effectiveness of the integrated intervention observed in the present study.

Gut–Brain Axis

One of the principal mechanisms underlying the observed improvements is modulation of the gut–brain axis, a bidirectional communication network involving the central nervous system, enteric nervous system, endocrine pathways, immune signaling, and intestinal

microbiota. Chronic psychological stress is known to impair intestinal motility through excessive activation of the hypothalamic–pituitary–adrenal (HPA) axis and sympathetic nervous system. Yoga practices, particularly meditation and pranayama, reduce stress-related neuroendocrine activation, thereby restoring autonomic balance and improving gastrointestinal function. The significant reduction in perceived stress scores observed in the intervention group supports this mechanism.

Parasympathetic Activation

Yoga is well recognized for enhancing parasympathetic nervous system activity through vagal stimulation. Slow breathing exercises such as Anulom Vilom, Ujjayi, and Bhramari increase vagal tone while reducing sympathetic dominance. Enhanced parasympathetic activity promotes gastric secretion, coordinated intestinal peristalsis, improved colonic transit, and efficient bowel evacuation. The regular practice of abdominal stretching and twisting postures may further stimulate intestinal smooth muscle activity and improve blood circulation to digestive organs.

Modulation of Gut Microbiota

Dietary intervention emphasizing fruits, vegetables, whole grains, legumes, and probiotic-rich foods likely promoted favorable changes in the intestinal microbiota. Increased microbial diversity supports intestinal health through production of short-chain fatty acids, maintenance of epithelial integrity, regulation of immune responses, and stimulation of intestinal motility. The combination of dietary fiber and probiotic intake may therefore have produced synergistic improvements in bowel function beyond those expected from either intervention alone.

Fiber Fermentation

Dietary fiber serves as the principal substrate for microbial fermentation within the colon. Fermentation produces short-chain fatty acids (SCFAs), including acetate, propionate, and butyrate, which stimulate colonic motility, improve epithelial nutrition, regulate inflammation, and enhance water retention within stool. Increased stool bulk together with improved intestinal lubrication facilitates easier bowel evacuation and reduces excessive straining during defecation. Consequently, the high-fiber dietary regimen prescribed in the present study likely contributed substantially to improvements in stool consistency and bowel frequency.

Psychological Relaxation

Functional constipation is strongly associated with anxiety, depression, and chronic psychological stress. Meditation, relaxation exercises, and mindful breathing improve emotional regulation by reducing cortisol secretion and enhancing psychological resilience. Participants in the intervention group demonstrated significant reductions in perceived stress, suggesting that psychological relaxation contributed to improved gastrointestinal functioning through normalization of autonomic activity and reduction of stress-induced bowel dysfunction. Thus, the benefits observed in this study appear to result from both physiological and psychological pathways operating simultaneously.

5.3 Clinical Implications

The findings of the present study have important implications for clinical practice and public health.

Non-Pharmacological Therapy

The study demonstrates that an integrated program of yoga and dietary modification can serve as an effective non-pharmacological therapeutic option for functional constipation. Such interventions may reduce dependence on long-term laxative therapy, minimize medication-related adverse effects, and improve overall patient well-being. Integrative lifestyle interventions may therefore be recommended as first-line management for uncomplicated functional constipation before initiation of prolonged pharmacological treatment.

Community Implementation

The intervention utilized in this study is practical and can be implemented in community health centers, yoga wellness clinics, primary healthcare facilities, educational institutions, workplaces, and elderly care centers. Because yoga requires minimal equipment and dietary modification relies largely on locally available foods, the intervention is highly adaptable across different socioeconomic settings. Community-based implementation could contribute significantly to reducing the burden of chronic constipation through preventive lifestyle modification.

Cost-Effectiveness

Compared with repeated physician consultations, long-term medication use, diagnostic investigations, and hospitalization resulting from constipation-related complications, yoga and dietary counseling represent cost-effective healthcare interventions. Once participants acquire appropriate knowledge and skills, they can continue these practices independently without substantial financial expenditure. Consequently, integrating yoga and nutrition education into routine healthcare services may substantially reduce both direct and indirect healthcare costs associated with chronic constipation.

5.4 Strengths of the Study

Several strengths enhance the scientific value of the present investigation.

First, the study adopted a randomized controlled trial design, which minimizes selection bias and strengthens causal inference regarding treatment effectiveness.

Second, the intervention employed a truly integrative approach, simultaneously incorporating yoga postures, pranayama, meditation, dietary modification, hydration guidance, and probiotic-rich nutrition. Such comprehensive interventions more accurately reflect real-world lifestyle medicine than isolated therapeutic strategies.

Third, multiple validated clinical outcome measures including the Constipation Severity Scale (CSS), Patient Assessment of Constipation Symptoms (PAC-SYM), Patient Assessment of Constipation Quality of Life (PAC-QOL), Bristol Stool Form Scale, bowel movement frequency, and Perceived Stress Scale provided a multidimensional assessment of treatment effectiveness.

Fourth, the intervention addressed both physiological and psychological determinants of functional constipation,

supporting the concept that gastrointestinal disorders require holistic rather than symptom-oriented management.

Finally, participant adherence was high, and no serious adverse events were reported, indicating that the intervention was both feasible and safe for routine clinical application.

5.5 Limitations

Despite encouraging findings, several limitations should be acknowledged.

First, the sample size was relatively small, which may limit statistical power and reduce the generalizability of the findings to larger and more diverse populations.

Second, the 12-week intervention period may not adequately capture the long-term sustainability of treatment benefits. Longer follow-up studies are required to determine whether improvements persist after completion of the intervention.

Third, the investigation was conducted at a single tertiary care center, potentially limiting external validity. Multicenter randomized controlled trials involving participants from different geographical regions and healthcare settings are necessary to confirm the present findings.

Fourth, adherence to dietary recommendations was assessed primarily through self-reported food diaries, making the possibility of recall bias and reporting bias unavoidable. Future studies may incorporate digital dietary monitoring, wearable devices, or nutritional biomarkers to improve measurement accuracy.

Additionally, the present study did not directly evaluate changes in gut microbiota composition or inflammatory biomarkers. Future investigations incorporating microbiome sequencing, metabolomic analysis, and neuroendocrine biomarkers would provide deeper insights into the biological mechanisms underlying integrative lifestyle interventions.

An additional limitation concerns the open-label design: participants could not be blinded to group allocation, since yoga participation is inherently apparent to those receiving it. Several outcome measures, including perceived stress, quality of life, and symptom scores, were self-reported and may therefore be susceptible to expectation or placebo effects. Future trials could incorporate blinded outcome assessors and objective physiological measures to help address this limitation.

Overall, despite these limitations, the present study provides robust preliminary evidence supporting the effectiveness of combining yoga and dietary modification as a comprehensive, safe, and clinically meaningful intervention for the management of functional constipation.

6. Conclusion

Functional constipation is a prevalent and multifactorial gastrointestinal disorder that significantly affects physical health, psychological well-being, and overall quality of life. The increasing prevalence of sedentary lifestyles, unhealthy dietary habits, inadequate hydration, and chronic psychological stress has further emphasized the need for comprehensive, non-pharmacological

management strategies. The present randomized controlled trial evaluated the effectiveness of an integrative intervention combining a structured yoga program with dietary modification in adults diagnosed with functional constipation according to the Rome IV criteria.

The findings of this study demonstrated that participants receiving the combined yoga and dietary intervention experienced statistically significant improvements in bowel movement frequency, stool consistency, constipation severity, constipation-related symptoms, quality of life, and perceived stress compared with those receiving standard lifestyle advice. The intervention also achieved a high level of participant adherence and was not associated with any serious adverse events, indicating that it is both safe and feasible for routine clinical implementation.

The observed improvements are likely attributable to the synergistic effects of multiple physiological mechanisms, including enhanced gastrointestinal motility, activation of the parasympathetic nervous system, regulation of the gut-brain axis, improved intestinal microbial balance, increased production of short-chain fatty acids through dietary fiber fermentation, and reduction of psychological stress through yoga and meditation. Unlike pharmacological therapies that primarily target symptom relief, the integrative intervention addressed the underlying lifestyle, behavioral, and psychosocial factors contributing to functional constipation.

From a clinical perspective, the findings provide strong evidence supporting the incorporation of structured yoga practices and individualized dietary counseling as complementary components of standard constipation management. Such interventions may reduce dependence on long-term laxative therapy, minimize medication-related adverse effects, improve patient satisfaction, and enhance long-term bowel health. Furthermore, because yoga and dietary modification are relatively inexpensive, culturally acceptable, and easily implementable, they represent practical therapeutic options for both hospital-based care and community health programs.

In conclusion, the present study demonstrates that an integrated lifestyle intervention consisting of yoga, pranayama, meditation, high-fiber nutrition, adequate hydration, and probiotic-rich dietary practices offers an effective, safe, and sustainable strategy for the management of functional constipation. Adoption of such holistic interventions has the potential to improve clinical outcomes, promote healthy lifestyle behaviors, and reduce the overall burden of functional gastrointestinal disorders. Future large-scale, multicenter clinical trials with longer follow-up periods and advanced biological assessments are warranted to further strengthen the evidence base and facilitate the integration of lifestyle medicine into routine gastroenterological practice.

7. Practical Recommendations

Based on the findings of the present study, the following recommendations are proposed for healthcare professionals and policymakers involved in the prevention and management of functional constipation.

7.1 Recommendations for Physicians

- ☐ Consider lifestyle modification as the first-line management strategy for uncomplicated functional constipation before initiating long-term pharmacological therapy.
- ☐ Encourage patients to adopt a high-fiber diet, maintain adequate hydration, and engage in regular physical activity.
- ☐ Recommend evidence-based yoga practices as complementary therapy alongside conventional medical treatment.
- ☐ Monitor patient progress using validated assessment tools such as the Constipation Severity Scale (CSS), Patient Assessment of Constipation Symptoms (PAC-SYM), and Bristol Stool Form Scale.
- ☐ Promote patient education regarding healthy bowel habits, regular meal timing, and stress management.

7.2 Recommendations for Gastroenterologists

- ☐ Incorporate multidisciplinary management involving yoga therapists and nutritionists into routine clinical care for patients with chronic functional constipation.
- ☐ Encourage individualized treatment plans based on patient symptoms, dietary patterns, psychological status, and lifestyle factors.
- ☐ Reserve long-term laxative therapy for patients who fail to respond adequately to lifestyle interventions.
- ☐ Consider microbiome-directed therapies, including probiotics and synbiotics, as adjunctive treatment where clinically appropriate.
- ☐ Support clinical research investigating integrative approaches for functional gastrointestinal disorders.

7.3 Recommendations for Yoga Therapists

- ☐ Develop standardized yoga protocols specifically designed for patients with functional constipation.
- ☐ Emphasize abdominal stretching, spinal twisting, breathing exercises, and relaxation techniques that stimulate gastrointestinal function.
- ☐ Include the following evidence-based practices in therapeutic sessions:
 - Pawanmuktasana
 - Vajrasana
 - Malasana
 - Ardha Matsyendrasana
 - Bhujangasana
 - Dhanurasana
 - Paschimottanasana
 - Shavasana
 - Anulom Vilom
 - Kapalabhati
 - Bhramari
 - Ujjayi Pranayama

- ☐ Encourage long-term adherence through supervised instruction and home-based practice modules.
- ☐ Monitor participants for contraindications and adapt yoga practices according to age and physical condition.

7.4 Recommendations for Nutritionists

- ☐ Promote individualized high-fiber dietary plans tailored to patient preferences and cultural food habits.
- ☐ Encourage regular consumption of:
 - o Whole grains
 - o Fruits
 - o Green leafy vegetables
 - o Legumes
 - o Nuts and seeds
 - o Fermented foods
 - o Probiotic-rich yogurt
- ☐ Educate patients regarding adequate daily water intake (approximately 2.5–3.0 liters unless medically contraindicated).
- ☐ Discourage excessive intake of processed foods, refined sugars, saturated fats, and sugar-sweetened beverages.

- ☐ Monitor dietary adherence through food diaries and periodic nutritional counseling.

7.5 Recommendations for Public Health Professionals

- ☐ Integrate yoga-based lifestyle interventions into national non-communicable disease prevention programs.
- ☐ Conduct community awareness campaigns emphasizing the importance of healthy dietary habits, hydration, physical activity, and bowel health.
- ☐ Establish community yoga centers promoting preventive gastrointestinal health.
- ☐ Include nutrition education and yoga practices within school and workplace wellness programs.
- ☐ Develop evidence-based clinical guidelines for integrative management of functional constipation.
- ☐ Encourage collaboration among physicians, gastroenterologists, yoga experts, dietitians, psychologists, and public health professionals to provide comprehensive patient-centered care.

Table 7.1 Practical Recommendations for Stakeholders

Stakeholder	Key Recommendations
Physicians	Early lifestyle intervention, patient education, evidence-based assessment
Gastroenterologists	Multidisciplinary care, individualized treatment, microbiome-based therapies
Yoga Therapists	Standardized yoga modules, supervised practice, long-term adherence
Nutritionists	High-fiber diet, hydration, probiotic-rich foods, dietary monitoring
Public Health Professionals	Community awareness, preventive programs, policy integration

8. Future Research

Although the present study provides encouraging evidence regarding the effectiveness of integrated yoga and dietary intervention for functional constipation, several areas warrant further investigation.

8.1 Multicenter Randomized Controlled Trials

Future research should involve multicenter randomized controlled trials with larger and more diverse populations recruited from different geographical regions. Such studies would improve external validity and facilitate the development of universally applicable clinical guidelines.

8.2 Long-Term Follow-Up Studies

The sustainability of therapeutic benefits remains uncertain. Longitudinal studies with follow-up periods of one to five years are needed to determine whether improvements in bowel function, quality of life, and psychological well-being are maintained over time.

8.3 Gut Microbiome Sequencing

Advances in metagenomics and next-generation sequencing provide opportunities to investigate changes in gut microbial diversity associated with integrated

lifestyle interventions. Future studies should examine microbial composition, functional metabolic pathways, and microbial biomarkers associated with treatment response.

8.4 AI-Assisted Bowel Monitoring

Artificial intelligence offers promising applications in gastrointestinal healthcare. Future investigations may utilize AI-based mobile applications capable of monitoring bowel habits, stool characteristics, dietary intake, medication adherence, and symptom progression while providing personalized recommendations and predictive risk assessment.

8.5 Wearable Technology

Wearable health devices capable of monitoring physical activity, sleep quality, heart rate variability, stress levels, and autonomic nervous system function may provide objective physiological indicators associated with constipation management. Integration of wearable sensors into clinical trials could improve assessment of treatment adherence and therapeutic outcomes.

8.6 Personalized Nutrition

Future research should investigate individualized nutritional interventions based on genetic profile,

microbiome composition, metabolic phenotype, dietary preferences, and lifestyle characteristics. Personalized dietary recommendations may maximize therapeutic efficacy while improving long-term adherence.

8.7 Precision Yoga Interventions

Emerging evidence suggests that different subtypes of functional constipation may respond differently to specific yoga practices. Future studies should develop precision yoga protocols tailored according to patient age, disease severity, pelvic floor dysfunction, autonomic nervous system status, psychological profile, and comorbid conditions. Combining precision yoga with personalized nutrition may represent an important advancement in integrative lifestyle medicine.

8.8 Biomarker-Based Research

Future investigations should evaluate inflammatory cytokines, cortisol levels, vagal tone, metabolomic profiles, and short-chain fatty acid production to better understand the biological mechanisms underlying integrated yoga and dietary interventions.

8.9 Digital Health and Tele-Yoga

Telemedicine platforms, mobile health applications, and virtual yoga instruction should be evaluated for their effectiveness in improving treatment accessibility, patient adherence, and long-term clinical outcomes, particularly among rural and underserved populations.

Table 8.1 Priority Areas for Future Research

Research Area	Expected Contribution
Multicenter RCTs	Improve generalizability and strengthen clinical evidence
Long-term follow-up	Assess durability of treatment effects
Gut microbiome sequencing	Elucidate microbial mechanisms and identify biomarkers
AI-assisted bowel monitoring	Enable real-time symptom tracking and personalized management
Wearable technology	Provide objective physiological and behavioral monitoring
Personalized nutrition	Optimize dietary interventions based on individual characteristics
Precision yoga interventions	Tailor yoga practices to patient-specific clinical profiles
Biomarker-based studies	Clarify molecular and physiological mechanisms of action
Digital health and tele-yoga	Expand accessibility and support long-term adherence

Overall, future interdisciplinary research integrating gastroenterology, nutrition science, yoga therapy, microbiome research, digital health technologies, artificial intelligence, and precision medicine will contribute substantially to the development of evidence-based, patient-centered strategies for the prevention and management of functional constipation.

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