

Current Insights on Vitamin D Intake, Status and Symptoms of Irritable Bowel Syndrome: A Narrative Review

Dolapo Olajumoke Enejoh¹, Monika Gostic²

¹Food Systems & Nutrition Advisor, Aberdeen Business School, Robert Gordon University, Aberdeen, UK

²Nutrition Science Lecturer, Institute of Medical Sciences, University of Aberdeen, Aberdeen, UK

Email: d.enejoh@rgu.ac.uk, dolapo.enejoh@gmail.com, Monika.gostic@abdn.ac.uk, drmonikagostic@gmail.com

How to cite this paper: Enejoh, D.O. and Gostic, M. (2024) Current Insights on Vitamin D Intake, Status and Symptoms of Irritable Bowel Syndrome: A Narrative Review. *Open Journal of Gastroenterology*, **14**, 348-367.

<https://doi.org/10.4236/ojgas.2024.1410037>

Received: September 5, 2024

Accepted: October 28, 2024

Published: October 31, 2024

Copyright © 2024 by author(s) and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

The association between Vitamin D and IBS has attracted growing interest because of vitamin D's involvement in immune system function and reduction of inflammation. IBS, a prevalent gastrointestinal condition marked by symptoms such as stomach pain, bloating, and changed bowel habits, implies that sufficient levels of Vitamin D may impact the symptomatology and quality of life associated with IBS. This review aimed to unveil current insights on vitamin D intake, status and symptoms of irritable bowel syndrome. A search was conducted on Embase, Scopus, Medline, and Cochrane Library, as well as a reference list of relevant studies. This paper also examined the current therapeutic practices for using vitamin D in the management of IBS. Although several studies demonstrate a positive association between vitamin D administration and the alleviation of IBS symptoms, the data is not yet definitive. Moreover, the review emphasised the necessity for additional rigorous clinical studies to determine a definitive therapeutic function of vitamin D in IBS based on the literature. The role of vitamin D in the modulation of gut health, particularly in IBS, has garnered significant attention due to its potential impact on both inflammation and the integrity of the gut barrier. Vitamin D, acting as a hormone precursor, is recognised for its crucial involvement in maintaining calcium balance and promoting bone health.

Keywords

Vitamin D, Irritable Bowel Syndrome, IBS, IBS Symptoms

1. Introduction

Vitamin D, a hormone precursor, is essential for maintaining calcium and phosphorus balance, regulating metabolism, and ensuring bone health [1] [2]. It also plays a role in cell differentiation and proliferation through endocrine and paracrine functions [3]. Research highlights the importance of vitamin D in extra-skeletal health in addition to its well-known role in skeletal health [4]-[8]. Vitamin D is naturally synthesised in the skin when exposed to solar ultraviolet B rays, but it can also be obtained through diet and supplements [9] [10].

In 2014, the British National Dietary and Nutrition Survey (NDNS) found a significant prevalence of vitamin D deficiency amongst healthy adults, with 39.3% having low serum 25-hydroxyvitamin D levels in the winter and 8.4% in the summer [11]. This deficiency has been linked to a variety of acute and chronic diseases, including autoimmune disease, cardiovascular disease, diabetes, cancer, and neurocognitive disorders [12]. Vitamin D deficiency in gastrointestinal diseases such as inflammatory bowel disease, coeliac disease, and cystic fibrosis is frequently caused by inadequate dietary intake, malabsorption, and insufficient sunlight exposure [13].

Vitamin D is unique amongst hormones in that it can be synthesised in the skin through sunlight exposure [6] [14]. It comes in two forms: ergocalciferol, which is found in mushrooms, and cholecalciferol, which is produced in the skin and found in oily fish [9]. Vitamin D is absorbed in the ileum and jejunum and transported with albumin and vitamin D-binding protein (DBP) [15]. Vitamin D is biologically inactive when it is synthesised and must be converted to its active form, 1,25-dihydroxyvitamin D (calcitriol), which acts on target tissues as a steroid bound to the vitamin D receptor (VDR) found on enterocytes, osteoblasts and distal renal tubule cells [16] and in several tissues, including the brain, prostate, breast, placenta, colonic epithelial cells, pancreatic islet cells, and immune cells [17].

1,25-dihydroxyvitamin D activates VDRs, stimulating cell differentiation whilst inhibiting proliferation, invasiveness, angiogenesis, and metastatic potential [18]. VDR gene polymorphisms have been associated with autoimmune diseases, insulin resistance, and Type 2 diabetes [6] [19]. Vitamin D can be obtained from sunlight, wild salmon, oily fish, cod liver oil, meat, egg yolk, and mushrooms [20]. Fortified foods also help with vitamin D intake [21]. In the United Kingdom, risk factors for vitamin D deficiency include pigmented skin, inadequate sunlight exposure, skin-concealing garments, strict sunscreen use, exclusive breastfeeding, multiple pregnancies, the elderly, obesity, institutionalisation, a vegetarian diet, and certain medical conditions [22] [23].

Serum calcium, phosphorus, fibroblast growth factor 23 (FGF-23), and parathyroid hormone (PTH) all play a role in regulating 1,25-dihydroxyvitamin D synthesis [24]. The primary storage form of vitamin D, 25-hydroxyvitamin D, is primarily found in the liver and adipose tissue [25]. Bellerba *et al.* [26] show that vitamin D has a major physiological influence on gut health, as its correlation with

the gut flora is clear. Building on the results of Naderpoor *et al.* [27], VDR is involved in immunoregulation of non-gastrointestinal infections, such as chlamydiosis, and lowers the risk of prolonged infection caused by *Chlamydia muridarum* by means of control of several secretable proteins, and He *et al.* [28] claim that variation of the human VDR gene “generates” the gut microbiome.

Under both diseased and healthy conditions, a non-randomised trial by Singh *et al.* [29] supplemented 80 vitamin D-deficient women with 50,000 IU of vitamin D per week for 12 weeks and showed a notable increase in the richness and diversity of their gut microbiomes, proving the capacity of vitamin D to modify and improve the gut microbiome. On the other hand, VDR loss not only causes metabolic problems in mice but also changes the structure of the gut microbiome and virome, hence affecting virus-microbiome interactions [30] [31]. Although findings of a study show that long-term vitamin D supplementation (60,000 IU/month) does not considerably change gut microbiome composition and diversity [32], analysis of another study suggests possible effects, albeit at a lower taxonomic level [27]. Perhaps elements like participant age and gender have had a role in the uneven effects of vitamin D and gut microbiota interactions [26] [33].

Studies reveal a relationship between vitamin D deficiency and some digestive problems since it has been shown to result in severe dysfunctions of the intestinal barrier and increased susceptibility to infectious agents, so changing the development and maintenance of gut homeostasis [34]-[37]. Gastrointestinal disorders, including inflammatory bowel disease (IBD), irritable bowel syndrome (IBS), and other illnesses including obesity and type 2 diabetes [38] [39], are connected to an imbalance of the normal gut microbiota. On the other hand, sufficient amounts of vitamin D have been linked to the integrity of junction complexes, therefore shielding the gut from damage [40] [41]. The link between low vitamin D levels and inflammatory bowel disease emphasises its significance in gut health [42] [43]. The main aim of this review was to investigate the relationship between vitamin D intake and IBS symptom severity and assess dietary patterns in people with IBS.

2. Methods

The methodology in this narrative review employed a traditional approach of exploring and conducting an extensive search across several databases, such as Embase, Scopus, Medline, and Cochrane Library, to identify relevant and recent literature relevant to this discussion on the insights on vitamin D intake, status, and symptoms of irritable bowel syndrome. This was conducted using several search terms and keywords such as “Vitamin D,” “Irritable Bowel Syndrome,” “IBS,” and “IBS symptoms.” This was done using various Boolean operators such as “AND,” “OR,” and “NOT” to combine search terms within and outside various spelling variants.

3. Irritable Bowel Syndrome

Naser *et al.* [44], defined irritable bowel syndrome (IBS) as a functional gastrointestinal

medical condition marked by persistent abdominal pain, bloating, and changes in bowel patterns, usually without any noticeable anatomical abnormalities. IBS is marked by a series of signs and symptoms that vary in intensity and frequency [45]. Moshiree *et al.* [46], outlined the primary symptoms, which include recurrent abdominal pain or discomfort, typically associated with changes in bowel habits such as diarrhoea (IBS-D), constipation (IBS-C), or alternating between both (IBS-M). Bloating, gas, and a sense of incomplete evacuation are also common, significantly impacting daily activities and quality of life [47]. Pasta *et al.* [48], stated that patients often report that symptoms worsen after eating, with specific foods like dairy, gluten, and high-FODMAP items acting as triggers. Additionally, extra-intestinal symptoms such as fatigue, headache, and sleep disturbances are frequently observed, reflecting the complexity of the gut-brain axis in IBS [49].

The Rome IV criteria include the occurrence of stomach discomfort on at least one day per week within the last 6 months, which should be related to defecation or a change in bowel pattern. In addition, stomach discomfort must satisfy at least two out of three criteria: it should be connected to faeces, along with a change in stool frequency, and coupled with a change in stool shape (appearance) [50]. Regarding stool consistency as assessed by the Bristol Stool Form Scale: Symptoms of IBS with constipation (IBS-C) hard or lumpy stools occurring more than 25% of the time and loose or watery stools occurring less than 25%. IBS with diarrhoea (IBS-D) is characterised by loose or watery stools occurring more than 25% of the time and hard or lumpy stools occurring less than 25% of the time. IBS with mixed bowel habits (IBS-M) is characterised by both diarrhoea and constipation occurring more than 25% of the time. IBS unclassified (IBS-U) is a subtype of IBS that is reserved for patients who do not meet the criteria for the other three [51].

Whilst IBS may not result in severe consequences like other gastrointestinal diseases, its persistent nature can greatly impact the quality of life for people given a diagnosis [52]. According to Sperber [53], globally, the estimated prevalence of IBS ranges from 4% to 10%, with variations within nations attributed to disparities in diagnostic criteria and awareness. A study by Sasegbon and Vasant [54], revealed a greater incidence in Western countries (10 - 15%) in comparison to Asian locations, where it varies from 4% to 8%; these geographical differences emphasise the influence of cultural, environmental, and genetic elements on the epidemiology of IBS. Furthermore, the condition is higher in prevalence amongst women compared to men, with a female-to-male ratio of around 2:1, indicating that hormonal and psychological elements may play a role in its development [55]. Also, Hafiz *et al.* [56], observed that the demographic most impacted is young adults between the ages of 20 and 40, possibly due to the interaction between stress, food, and other lifestyle elements prevalent in this age bracket. This phenomenon renders IBS a worldwide public health concern necessitating customised therapeutic approaches amongst diverse populations [57].

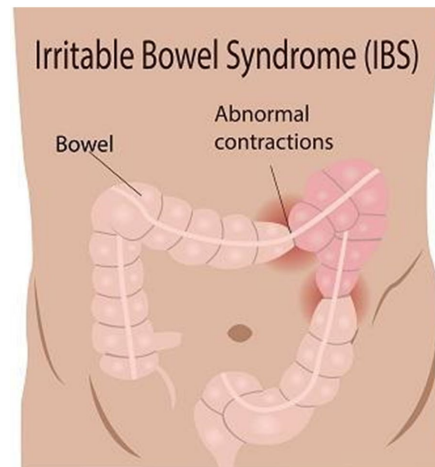


Figure 1. Depicts the anatomical position of IBS (Source: [58]). (Retrieved from <https://www.midvalleygi.com/blog/321672-symptoms-and-treatment-of-irritable-bowel-syndrome>).

3.1. Impact of IBS on Its Management

IBS-C mostly affects delayed colonic transit and difficulties in stool passing [59]-[61]. Although some patients may feel fibre aggravates bloating and pain, treatment of IBS-C consists of dietary changes, including increasing fibre intake. Laxatives and secretagogues such as lubiprostone or linaclotide, which increase intestinal fluid flow to help bowel motions, are common pharmacological therapies for pharmacological interventions that include laxatives and secretagogues. Certain patients benefit from prokinetic drugs that increase gastrointestinal motility. Patients with significant pelvic floor dysfunction linked to IBS-C may also find benefit from behavioural therapy such as biofeedback [60] [62] [63]. Controlling bowel habits typically leads to a positive long-term prognosis, although individuals with IBS-C often react to therapy more slowly than those with other conditions. Many patients also find relief over time. Still, the return of symptoms is somewhat usual [64].

Altomare *et al.* [65] suggests that fast colonic transit is defined by IBS-D causes regular loose stools. Most times, management plans focuses on antidiarrheal medications like loperamide, which inhibits gastrointestinal motility. Patients with bile acid malabsorption—a prominent cause of IBS-D—also take bile acid sequestrants such as cholestyramine [66]. Particularly the adoption of a low FODMAP (fermentable oligosaccharides, disaccharides, monosaccharides, and polyols) diet, dietary changes have demonstrated efficiency in lowering symptoms such as bloating and diarrhoea [67]. Approved for treatment of IBS-D, the non-absorbable antibiotic Rifaximin modulates gut flora [68]. Patients with IBS-D often have a changing course with periods of aggravation and remission; if dietary and pharmacological treatments are successful, the prognosis is usually good. A fraction of patients, meantime, can have severe and refractory symptoms that call for long-term treatment plans [69].

Because of alternating constipation and diarrhoea, IBS-M poses a more difficult management issue; therapy is thus more difficult. Dietary therapy usually consists of a trial of a low-FODMAP diet or a slow introduction of fibre to stabilise bowel movements [70]. According to Cangemi and Lacy [66], pharmacological treatments have to target both symptoms; some individuals need both laxatives and antidiarrheals depending on their symptomatology at any one moment. Given the erratic and frequently unexpected character of the symptoms, psychological interventions like cognitive-behavioural therapy (CBT) may be especially crucial in IBS-M [71]. Often aggravating IBS symptoms, these treatments help control the worry and stress. With patients generally undergoing frequent variations in symptom patterns, IBS-M often has a more varied prognosis than other subtypes. The erratic character of the bowel motions makes management techniques difficult. Most patients, however, may eventually attain satisfactory symptom management with appropriate care [72].

Less clearly defined than the other subtypes, IBS-U identifies individuals who fall outside of IBS-C, IBS-D, or IBS-M criteria. Treatment is thus typically empirical, with an eye towards symptom reduction depending on the most troublesome symptoms the patient reports [67]. Whether constipation or diarrhoea predominates at various periods, Jayasinghe *et al.* [67] suggest that dietary guidance and lifestyle changes are frequently the first line of therapy, followed by pharmaceutical medications catered to the patient's symptom pattern. Mearin *et al.* [51] underline that the prognosis is varied and mostly relies on how effectively the patient's symptoms can be categorised and controlled over time because of the diverse character of IBS-U. As their symptoms change, some individuals could move into a more specific subtype whilst others might stay in the IBS-U range long-term [51].

Moreover, depending on the subtype to target the main symptoms—constipation, diarrhoea, or a mix—treatment is tailored. The long-term prognosis of the patient depends frequently on the effectiveness of the treatment techniques. Whilst IBS-M frequently needs more complex treatments, IBS-D and IBS-C may react more consistently to pharmaceutical therapies [72]. Black *et al.* [73] claim that because of the changing nature of symptoms, IBS-M and IBS-U might have less predictable results. If symptoms are controlled, most IBS sufferers have a positive prognosis; however, since the condition is chronic and relapsing, long-term follow-up is usually necessary [74].

3.2. Current Trends on IBS Management

Technological advancements in digital health have enabled the real-time monitoring of vitamin D levels and symptoms of irritable bowel syndrome (IBS) using wearable devices and smartphone apps [75]. Peroni *et al.* [6] described these findings as a means to facilitate continuous data collection, enabling more accurate correlations between vitamin D levels and occurrences of IBS, thereby providing patients with the knowledge to enhance their illness management. Furthermore,

artificial intelligence-powered computers have the potential to transform the diagnosis of irritable bowel syndrome. Currently, the diagnosis of IBS relies on criteria based on symptoms (Rome IV), although this approach often results in incorrect diagnoses or delayed detection [51]. Machine learning algorithms have the potential to uncover concealed patterns by analysing extensive datasets from diverse clinical, genetic, and microbiome-based research, enabling earlier and more precise diagnoses [75]. AI algorithms may use symptom severity ratings, patient history, and physiological factors to predict the specific subtype of IBS a patient has and suggest tailored treatment approaches [76]. Furthermore, artificial intelligence may include indicators such as the makeup of gut microbiota, which is becoming generally acknowledged as a factor in the pathogenesis of irritable bowel syndrome [77]. AI has the potential to reduce the frequency of superfluous referrals for colonoscopy and biopsy, resulting in time and cost savings [75].

Using nanotechnology in stool analysis or imaging of the intestines could make it easier to track how well treatments are working by giving continuous information about how well medications are absorbed and how healthy the gut is. Improving this feedback loop has the potential to optimise treatment strategies, providing more individualised treatments, and improving the outlook for patients with refractory irritable bowel syndrome [78]. Both artificial intelligence (AI) and nanotechnology have the potential to provide more accurate and efficient treatments, therefore alleviating the reliance on trial-and-error methods that are already prevalent in the management of irritable bowel syndrome (IBS) [74]. Patients can expect superior management of symptoms, reduced occurrence of exacerbations, and an improved general state of health through timely identification, higher precision in diagnosis, and customised therapeutic interventions. Nanotechnology in vitamin D delivery systems has emerged as a very promising strategy for enhancing vitamin D absorption and efficacy in people with IBS. The objective is to optimise its therapeutic advantages whilst minimising any potential adverse effects [79]. Despite the considerable potential of these technologies, further study is required to confirm their effectiveness in clinical practice. Empirical investigations combining artificial intelligence models with patient data are crucial to guaranteeing the dependability and applicability of these methodologies. Additionally, studies involving humans are needed to find out if nanotechnology advances are safe, effective, and have any long-term effects on people who have irritable bowel syndrome (IBS) [80].

3.3. Role of Vitamin D in Modulating Gut Health and Inflammation in IBS Patients

Yu *et al.* [81], observed that vitamin D plays a critical role in the pathophysiology of IBS by regulating inflammation and gut health. Aribi *et al.* [82], recognised vitamin D for its immunomodulatory characteristics and its ability to maintain the normal functioning of the gut barrier. It modulates gut microbiota composition and reduces intestinal inflammation by regulating immune cell activity and

cytokine production [83]. Williams *et al.* [84]; Williams, Williams and Corfe [85]; and Williams [86], highlighted that insufficient levels of vitamin D to heightened gut permeability, which can initiate or worsen symptoms of IBS by facilitating the movement of bacterial metabolites that stimulate immunological responses. Linsalata *et al.* [87], revealed that people with IBS, especially IBS-D, often have lower blood vitamin D levels than those without the condition. Vitamin D supplement administration resulted in symptom improvement in certain individuals by reducing abdominal discomfort and regulating bowel movements [88]. Matthews *et al.* [89] also supported the concept that a lack of vitamin D may contribute to the severity of symptoms associated with IBS. Nevertheless, much controversy persists over the consistent nature of these results. Although several studies provide evidence for the advantages of vitamin D supplementation in individuals with IBS, other studies present restricted or ambiguous findings [90]. A randomised controlled research conducted by Chong *et al.* [91], found that vitamin D treatment had low efficacy in alleviating IBS symptoms when compared to a placebo group. Yu *et al.* [81], added that variations in patient subgroups, initial vitamin D levels, and the recommended dosage or period of supplementation may account for the discrepancy. Moreover, although vitamin D may have positive effects on individuals with IBS by regulating the composition of gut microbiota and decreasing inflammation, several studies suggest that these benefits are more pronounced in patients with severe deficiency and may be insignificant in those with levels that are on the borderline [92]. Agrawal *et al.* [93], suggested that vitamin D may not have a significant influence on the management of IBS, with lifestyle elements such as nutrition and stress management playing a more significant role in symptom relief.

3.4. Dietary Sources and Recommendations for Vitamin D Intake in IBS Management

For the treatment of IBS, proper dietary sources of vitamin D and adherence to consumption requirements are crucial, as adequate levels are required to preserve gut health, control the immune system, and calm inflammation [94]. Mishra *et al.* [95] suggested sources like food consumption, dietary supplements, and solar exposure may provide vitamin D. Highly plentiful naturally occurring sources of vitamin D include omega-3 fatty fish like salmon, mackerel, and sardines [96]. For adults, the Institute of Medicine's general recommended daily vitamin D consumption varies from 600 to 800 IU (15 to 20 µg), with a maximum safe limit of 4,000 IU (100 µg) [97]. Experts globally hold the belief that supplementing with vitamin D should occur independently of one's eating patterns. In the United Kingdom, the Scientific Advisory Committee on Nutrition (SACN) [98] advises a safe vitamin D consumption of 340 - 400 IU/day in babies, 400 IU/day in children aged between 1 and 4 years, and 400 IU/day for the population aged 4 years and over. According to the European Food Safety Authority (2016), an intake of 400 IU/day in newborns between 7 and 11 months and 600 IU/day in paediatric

subjects aged 1 - 17 years could be sufficient to avoid additional difficulties related to vitamin D shortage [99].

Despite the lack of widely accepted dietary recommendations for vitamin D consumption in IBS patients, recent research suggests that enhancing vitamin D levels could potentially improve symptoms and overall quality of life. Given studies indicate a link between vitamin D insufficiency and IBS symptom severity, consumption of vitamin D in IBS care may call for tailored changes. Abbasnezhad *et al.* [100] did a double-blind, randomised, placebo-controlled study on IBS patients with IBS-D (diarrhoea-predominant IBS). The results showed that IBS patients who got 50,000 IU of vitamin D3 or a placebo every two weeks had much better IBS symptoms than those who got the placebo. This implies that periodic greater doses—that is, weekly rather than daily—may also be beneficial in relieving symptoms. Jalili *et al.* [101] recorded comparable results in a trial that included IBS patients who received IBS and supplemented weekly with either a pearl of 50,000 IU Vitamin D or an identical pearl of placebo containing medium chain triglyceride for six weeks. According to the findings, patients with IBS demonstrated better quality of life and symptom levels. Battistini *et al.* [102] indicated that vitamin D may enhance gut barrier function and lower intestinal permeability, thereby helping to control IBS symptoms by improving gut health. This suggests how vitamin D modulates gut bacteria, which is known to be changed in IBS patients. In this regard, enough dietary vitamin D consumption might help to balance gut flora; further clinical trials are needed to validate these conclusions. Nonetheless, given considerations like geographical location, sun exposure, and baseline blood vitamin D levels, vitamin D supplementation should be tailored depending on specific requirements [103]. For IBS patients taking supplements, regular monitoring of blood 25-hydroxyvitamin D levels—every three to six months—is advised [104].

Individuals with IBS—especially those who are deficient—often need more vitamin D [95]. Radziszewska *et al.* [70] suggest that IBS patients could benefit from daily dosages as high as 2000 IU, as they believe this higher intake could more effectively alleviate symptoms related to gut health and immune function. Apart from supplements, Dominguez *et al.* [105] underlined that maintaining adequate vitamin D levels depends critically on lifestyle choices, including sun exposure. Although for those with IBS living in areas with limited sunlight or those with darker skin tones, the relevance of food sources and supplements becomes more evident. Webb *et al.* [106] noted solar radiation as the most natural and effective means of obtaining vitamin D, as even short durations of exposure (10 - 30 minutes) are sufficient for most people during periods of highest UVB intensity. Despite efforts to improve their nutritional intake, those with IBS living in northern latitudes or those with little outdoor exercise showed a greater incidence of vitamin D deficiency [86]. Therefore, to improve overall wellness and gastrointestinal health, individuals with IBS should combine dietary sources and recommendations with lifestyle changes and tailored treatment, even though they are crucial

in lowering vitamin D levels [107].

3.5. Impact of Vitamin D Supplementation on Symptom Management in IBS

In recent times, the effects of vitamin D supplementation on the control of symptoms in IBS have been the subject of extensive research and discussion [108]. Pagnini *et al.* [109], suggested that there's a possibility that vitamin D could help ease the symptoms of IBS, since it affects the immune system, keeps the gut barrier strong, and changes the gut microbiome. A research by Radziszewska *et al.* [70], indicated that vitamin D administration can result in substantial reductions in stomach discomfort, bloating, and overall symptom intensity in persons with IBS. Zeraattalab-Motlagh *et al.* [110], conducted a randomised controlled trial (RCT) in which they found that vitamin D supplementation significantly reduced stomach pain and bloating in patients with IBS compared to those who received a placebo. Vernia *et al.* [111], posited that vitamin D's anti-inflammatory properties and contribution to gut mucosal integrity may account for the amelioration of symptoms. Also Wang *et al.* [112], in a comprehensive review, revealed that widespread vitamin D insufficiency amongst individuals with IBS, and suggested that supplementation could alleviate symptoms by bolstering the immune system and reducing intestinal permeability.

Notwithstanding these positive findings, there is contradicting evidence casting questions on the efficacy of vitamin D supplementation in IBS symptom treatment. Variations in study design, sample size, and supplementation duration generally cause differences in the research results. Shorter studies might not be able to adequately reflect how vitamin D affects IBS symptoms over time. Furthermore, some studies use diverse vitamin D dosages—from low daily doses (600 - 800 IU) to higher periodic doses (50,000 IU weekly)—which might affect results. The Abbasnezhad *et al.* [100] study used standard doses, but the absence of predicted benefits highlights the potential complexity of IBS pathophysiology, which may not respond consistently to vitamin D. Given the subjective nature of symptom reporting in IBS studies, the placebo effect is also typically significant. Psychological elements such as stress and worry might affect IBS symptoms like discomfort, bloating, and bowel abnormalities, complicating the interpretation of the findings. Moreover, IBS is a complex disorder characterised by gut-brain axis malfunction, altered gut motility, visceral hypersensitivity, and immune system dysregulation. Although vitamin D is well-known for its influence on immune modulation and inflammatory management, its direct effect on other IBS-related processes, including motility or visceral sensitivity, is unknown. Managing IBS calls for a multifarious strategy including dietary modifications, stress management, and various pharmaceutical therapies, Mendes *et al.* [108] asserted that vitamin D should not be considered as a main therapy. Rather, it might be a complementing indicator, especially for those with established deficits.

3.6. Implications of This Review

This review has major importance for enhancing our knowledge of the correlation between vitamin D consumption and IBS. Traditionally, vitamin D has extensively been studied for its impact on bone health and immunological function. However, in recent times, its association with gastrointestinal health has gradually been established, particularly in relation to IBS. This study synthesises developing data suggesting Vitamin D has a crucial function in regulating the gut flora, decreasing inflammation, and potentially relieving symptoms of IBS. The importance of these observations lies in their ability to expand our historical understanding of vitamin D beyond its usual limits. This highlights its wider impact on health and its potential as a therapeutic intervention in the treatment of IBS. This not only deepens our understanding of the many advantages of Vitamin D, but also stimulates further investigation into its ideal consumption for people with IBS. The recognition of the impact of Vitamin D on gastrointestinal well-being signifies a significant advancement in nutrition and medicine, offering a more holistic approach to the management of IBS and associated conditions. Furthermore, it highlights the revolutionary impact of Artificial Intelligence (AI) technologies in the diagnosis of (IBS), which augments the knowledge of the advantages of Vitamin D. Optimising the therapeutic potential of nutrients like Vitamin D reduces the risk of unwanted effects and enhances the overall effectiveness of treatment programs.

4. Limitations

This review did not adhere to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) recommendations, which aim to improve the clarity and scientific rigour of systematic reviews [113]. In the absence of a well-defined PRISMA framework, important elements such as the selection of studies, extraction of data, and synthesis of findings may not meet the usual standards of rigour and repeatability in systematic reviews. It lacked a comprehensive evaluation of the quality of the examined research. Also, it did not assess the methodological rigour of the studies included in the analysis, which poses a potential danger of allowing biases or inconsistencies in the source research to impact the conclusions [114]. Also, the lack of quality assessment makes it harder to tell how reliable and accurate the results are, which could lead to either an overestimation or underestimation of how Vitamin D affects IBS. The possibility of publication bias poses a further constraint, as the review may have primarily included papers with favourable results, potentially underrepresenting studies with unfavourable or equivocal findings. In addition, the wide range of study designs, populations, and interventions explored in the included literature may have limited the review, potentially complicating the process of reaching conclusive findings.

5. Recommendations for Future Research

The exact processes via which vitamin D might affect IBS symptoms are still

unknown. Studies on how vitamin D alters gut motility, visceral sensitivity, and the gut-brain axis including how vitamin D interacts with the microbiota and intestinal permeability may help one better understand why some IBS patients get advantages from supplements whilst others do not. Moreover, opinions on the suitable amount and duration of vitamin D therapy for IBS patients vary widely. Future research should concentrate on finding the ideal supplement plan catered to IBS subtypes (IBS-D, IBS-C, and IBS-M) and different degrees of vitamin D shortage. Comparative studies looking at low vs. high dosages over many times might help to define the ideal therapy strategy. Still, considering the variety of IBS, future research should concentrate on individualised therapy approaches. Studies on environmental and genetic elements—such as sun exposure, nutrition, and gut microbiota composition—that affect personal reactions to vitamin D supplementation might help to clarify highly beneficial would be stratified clinical studies depending on baseline vitamin D levels, IBS subtype, and patient demographics.

6. Conclusion

Concerning IBS as a complicated gastrointestinal disease with many subtypes (IBS-C, IBS-D, IBS-M, and IBS-U), with each needing focused treatment methods, this review has attracted much interest. Although IBS causes no major physical damage, patients' quality of life is much affected by its chronic character. Depending on the subtype, effective therapy often combines psychological treatments, pharmaceutical measures, and dietary changes. Because of alternating symptoms, IBS-M poses greater difficulties and calls for a comprehensive treatment combining psychological assistance with dietary changes. Because vitamin D helps to control inflammation and preserve gut health, it has attracted interest as a possible modulator of IBS symptoms. Particularly in people with deficits, studies show that vitamin D supplements may help with symptoms like bowel abnormalities, bloating, and stomach discomfort. However, vitamin D's advantages vary depending on research; some point to limited effectiveness whilst others offer favourable results. Individual variances in IBS aetiology, dose of supplements, and baseline vitamin D levels most certainly affect these differences. Current advances suggest improvements in IBS care including the use of nanotechnology for enhanced vitamin D delivery and artificial intelligence for customised treatment regimens. Although vitamin D supplements might be a complementary therapy, their function should be considered part of a larger, multifaceted strategy to control IBS, including dietary modifications, stress management, and conventional therapies. More extensive research is needed to define the complete value of vitamin D in IBS treatment and improve customised therapy approaches.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] Wimalawansa, S.J. (2023) Physiological Basis for Using Vitamin D to Improve Health. *Biomedicines*, **11**, Article 1542. <https://doi.org/10.3390/biomedicines11061542>
- [2] Verlinden, L. and Carmeliet, G. (2024) Vitamin D and Bone: An Integrated Approach. In: Hewison, M., *et al.*, Eds., *Feldman and Pike's Vitamin D*, Elsevier, 435-452. <https://doi.org/10.1016/b978-0-323-91386-7.00004-0>
- [3] Bender, D. (2011) Fat-Soluble Vitamins. In: Geissler, C. and Powers, H., Eds., *Human Nutrition (12th edition)*, Elsevier, 225-244.
- [4] Giustina, A., Bilezikian, J.P., Adler, R.A., Banfi, G., Bikle, D.D., Binkley, N.C., *et al.* (2024) Consensus Statement on Vitamin D Status Assessment and Supplementation: Whys, Whens, and Hows. *Endocrine Reviews*, **45**, 625-654. <https://doi.org/10.1210/endrev/bnae009>
- [5] Rejnmark, L., Bislev, L.S., Cashman, K.D., Eiriksdottir, G., Gaksch, M., Grübler, M., *et al.* (2017) Non-Skeletal Health Effects of Vitamin D Supplementation: A Systematic Review on Findings from Meta-Analyses Summarizing Trial Data. *PLOS ONE*, **12**, e0180512. <https://doi.org/10.1371/journal.pone.0180512>
- [6] Peroni, D.G., Nuzzi, G., Bernardini, R., Landi, M., Martelli, A., Capristo, C., *et al.* (2024) Vitamin D and Child Health: From the Controversy to the Novel Therapeutic Approaches. *Global Pediatrics*, **7**, Article ID: 100100. <https://doi.org/10.1016/j.gpeds.2023.100100>
- [7] Crescioli, C. (2020) Vitamin D Merging into Immune System-Skeletal Muscle Network: Effects on Human Health. *Applied Sciences*, **10**, Article 5592. <https://doi.org/10.3390/app10165592>
- [8] Zheng, X., Lin, J., Huang, J., Wu, T. and Song, C. (2023) Targeting Aging with the Healthy Skeletal System: The Endocrine Role of Bone. *Reviews in Endocrine and Metabolic Disorders*, **24**, 695-711. <https://doi.org/10.1007/s11154-023-09812-6>
- [9] Holick, M.F. (2007) Vitamin D Deficiency. *New England Journal of Medicine*, **357**, 266-281. <https://doi.org/10.1056/nejmra070553>
- [10] Laird, E., Ward, M., McSorley, E., Strain, J.J. and Wallace, J. (2010) Vitamin D and Bone Health; Potential Mechanisms. *Nutrients*, **2**, 693-724. <https://doi.org/10.3390/nu2070693>
- [11] National Dietary and Nutrition Survey (NDNS) (2014) National Diet and Nutrition Survey Results from Years 1, 2, 3 and 4 (Combined) of the Rolling Programme (2008/2009-2011/2012).
- [12] Hossein-Nezhad, A. and Holick, M.F. (2013) Vitamin D for Health: A Global Perspective. *Mayo Clinic Proceedings*, **88**, 720-755. <https://doi.org/10.1016/j.mayocp.2013.05.011>
- [13] Sizar, O., Khare, S., Goyal, A., Bansal, P., and Givler, A. (2021) Vitamin D Deficiency. StatPearls.
- [14] Alshahrani, F. and Aljohani, N. (2013) Vitamin D: Deficiency, Sufficiency and Toxicity. *Nutrients*, **5**, 3605-3616. <https://doi.org/10.3390/nu5093605>
- [15] Bikle, D.D. (2012) Vitamin D and Bone. *Current Osteoporosis Reports*, **10**, 151-159. <https://doi.org/10.1007/s11914-012-0098-z>
- [16] Christakos, S., Hewison, M., Gardner, D.G., Wagner, C.L., Sergeev, I.N., Rutten, E., *et al.* (2013) Vitamin D: Beyond Bone. *Annals of the New York Academy of Sciences*, **1287**, 45-58. <https://doi.org/10.1111/nyas.12129>

- [17] Wacker, M. and Holick, M. (2013) Vitamin D—Effects on Skeletal and Extraskelatal Health and the Need for Supplementation. *Nutrients*, **5**, 111-148. <https://doi.org/10.3390/nu5010111>
- [18] Autier, P. (2007) Vitamin D Supplementation and Total Mortality Meta-Analysis of Randomized Controlled Trials. *Archives of Internal Medicine*, **167**, 1730-1737. <https://doi.org/10.1001/archinte.167.16.1730>
- [19] Mohammed, A.A., El-Matty, D.M.A., Abdel-Azeem, R., Raafat, K., Hussein, M.A., El-Ansary, A.R., *et al.* (2023) Allelic Discrimination of Vitamin D Receptor Polymorphisms and Risk of Type 2 Diabetes Mellitus: A Case-Controlled Study. *Healthcare*, **11**, Article 485. <https://doi.org/10.3390/healthcare11040485>
- [20] Holick, M.F. (2011) Vitamin D: A D-Lightful Solution for Health. *Journal of Investigative Medicine*, **59**, 872-880. <https://doi.org/10.2310/jim.0b013e318214ea2d>
- [21] Pearce, S.H. and Cheetham, T.D. (2010) Diagnosis and Management of Vitamin D Deficiency. *BMJ*, **340**, b5664-b5664. <https://doi.org/10.1136/bmj.b5664>
- [22] Sha, S., Chen, L., Brenner, H. and Schöttker, B. (2023) Associations of 25-Hydroxyvitamin D Status and Vitamin D Supplementation Use with Mortality Due to 18 Frequent Cancer Types in the UK Biobank Cohort. *European Journal of Cancer*, **191**, Article ID: 113241. <https://doi.org/10.1016/j.ejca.2023.113241>
- [23] Sharipova, N.M. (2023) Impact of Vitamin D Deficiency on Pregnancy. *Central Asian Journal of Medical and Natural Science*, **4**, 705-712.
- [24] Portales-Castillo, I. and Simic, P. (2022) PTH, FGF-23, Klotho and Vitamin D as Regulators of Calcium and Phosphorus: Genetics, Epigenetics and Beyond. *Frontiers in Endocrinology*, **13**, Article 992666. <https://doi.org/10.3389/fendo.2022.992666>
- [25] Park, C.Y. and Han, S.N. (2021) The Role of Vitamin D in Adipose Tissue Biology: Adipocyte Differentiation, Energy Metabolism, and Inflammation. *Journal of Lipid and Atherosclerosis*, **10**, 130-144. <https://doi.org/10.12997/jla.2021.10.2.130>
- [26] Bellerba, F., Muzio, V., Gnagnarella, P., Facciotti, F., Chiocca, S., Bossi, P., *et al.* (2021) The Association between Vitamin D and Gut Microbiota: A Systematic Review of Human Studies. *Nutrients*, **13**, Article 3378. <https://doi.org/10.3390/nu13103378>
- [27] Naderpoor, N., Mousa, A., Fernanda Gomez Arango, L., Barrett, H.L., Dekker Nitert, M. and de Courten, B. (2019) Effect of Vitamin D Supplementation on Faecal Microbiota: A Randomised Clinical Trial. *Nutrients*, **11**, Article 2888. <https://doi.org/10.3390/nu11122888>
- [28] He, Q., Ananaba, G.A., Patrickson, J., Pitts, S., Yi, Y., Yan, F., *et al.* (2013) Chlamydial Infection in Vitamin D Receptor Knockout Mice Is More Intense and Prolonged than in Wild-Type Mice. *The Journal of Steroid Biochemistry and Molecular Biology*, **135**, 7-14. <https://doi.org/10.1016/j.jsbmb.2012.11.002>
- [29] Singh, P., Rawat, A., Alwakeel, M., Sharif, E. and Al Khodor, S. (2020) The Potential Role of Vitamin D Supplementation as a Gut Microbiota Modifier in Healthy Individuals. *Scientific Reports*, **10**, Article No. 21641. <https://doi.org/10.1038/s41598-020-77806-4>
- [30] Jin, D., Wu, S., Zhang, Y., Lu, R., Xia, Y., Dong, H., *et al.* (2015) Lack of Vitamin D Receptor Causes Dysbiosis and Changes the Functions of the Murine Intestinal Microbiome. *Clinical Therapeutics*, **37**, 996-1009.e7. <https://doi.org/10.1016/j.clinthera.2015.04.004>
- [31] Zhang, J., Zhang, Y., Xia, Y. and Sun, J. (2021) Imbalance of the Intestinal Virome and Altered Viral-Bacterial Interactions Caused by a Conditional Deletion of the Vitamin D Receptor. *Gut Microbes*, **13**, Article ID: 1957408. <https://doi.org/10.1080/19490976.2021.1957408>

- [32] Pham, H., Waterhouse, M., Rahman, S., Baxter, C., Duarte Romero, B., McLeod, D.S.A., *et al.* (2023) The Effect of Vitamin D Supplementation on the Gut Microbiome in Older Australians—Results from Analyses of the D-Health Trial. *Gut Microbes*, **15**, Article ID: 2221429. <https://doi.org/10.1080/19490976.2023.2221429>
- [33] Murdaca, G., Tagliafico, L., Page, E., Paladin, F. and Gangemi, S. (2024) Gender Differences in the Interplay between Vitamin D and Microbiota in Allergic and Auto-immune Diseases. *Biomedicines*, **12**, Article 1023. <https://doi.org/10.3390/biomedicines12051023>
- [34] Toriki, M., Gholamrezaei, A., Mirbagher, L., Danesh, M., Kheiri, S. and Emami, M.H. (2015) Vitamin D Deficiency Associated with Disease Activity in Patients with Inflammatory Bowel Diseases. *Digestive Diseases and Sciences*, **60**, 3085-3091. <https://doi.org/10.1007/s10620-015-3727-4>
- [35] Assa, A., Vong, L., Pinnell, L.J., Avitzur, N., Johnson-Henry, K.C. and Sherman, P.M. (2014) Vitamin D Deficiency Promotes Epithelial Barrier Dysfunction and Intestinal Inflammation. *Journal of Infectious Diseases*, **210**, 1296-1305. <https://doi.org/10.1093/infdis/jiu235>
- [36] Avan, A., Ghayour-Mobarhan, M., Tabatabaeizadeh, S., Tafazoli, N. and Ferns, G. (2018) Vitamin D, the Gut Microbiome and Inflammatory Bowel Disease. *Journal of Research in Medical Sciences*, **23**, 75. https://doi.org/10.4103/jrms.jrms_606_17
- [37] Raman, M., Milestone, A.N., Walters, J.R.F., Hart, A.L. and Ghosh, S. (2010) Vitamin D and Gastrointestinal Diseases: Inflammatory Bowel Disease and Colorectal Cancer. *Therapeutic Advances in Gastroenterology*, **4**, 49-62. <https://doi.org/10.1177/1756283x10377820>
- [38] Bull, M.J. and Plummer, N.T. (2014) Part 1: The Human Gut Microbiome in Health and Disease. *Integrative Medicine*, **13**, 17-22.
- [39] Hills, R., Pontefract, B., Mishcon, H., Black, C., Sutton, S. and Theberge, C. (2019) Gut Microbiome: Profound Implications for Diet and Disease. *Nutrients*, **11**, Article 1613. <https://doi.org/10.3390/nu11071613>
- [40] Shang, M. and Sun, J. (2017) Vitamin D/VDR, Probiotics, and Gastrointestinal Diseases. *Current Medicinal Chemistry*, **24**, 876-887. <https://doi.org/10.2174/0929867323666161202150008>
- [41] Lu, R., Wu, S., Xia, Y. and Sun, J. (2012) The Vitamin D Receptor, Inflammatory Bowel Diseases, and Colon Cancer. *Current Colorectal Cancer Reports*, **8**, 57-65. <https://doi.org/10.1007/s11888-011-0114-1>
- [42] Reich, K.M. (2014) Vitamin D Improves Inflammatory Bowel Disease Outcomes: Basic Science and Clinical Review. *World Journal of Gastroenterology*, **20**, 4934-4947. <https://doi.org/10.3748/wjg.v20.i17.4934>
- [43] Feldman, D., Krishnan, A.V., Swami, S., Giovannucci, E. and Feldman, B.J. (2014) The Role of Vitamin D in Reducing Cancer Risk and Progression. *Nature Reviews Cancer*, **14**, 342-357. <https://doi.org/10.1038/nrc3691>
- [44] Naser, M., Naser, M.M. and Shehata, L.H. (2021) IBS Clinical Review. *International Journal of Scientific Progress & Research*, **27**, 83-99.
- [45] Camilleri, M. (2021) Diagnosis and Treatment of Irritable Bowel Syndrome: A Review. *JAMA*, **325**, 865-877. <https://doi.org/10.1001/jama.2020.22532>
- [46] Moshiree, B., Heidelbaugh, J.J. and Sayuk, G.S. (2022) A Narrative Review of Irritable Bowel Syndrome with Diarrhea: A Primer for Primary Care Providers. *Advances in Therapy*, **39**, 4003-4020. <https://doi.org/10.1007/s12325-022-02224-z>
- [47] Wilkinson, J.M. and Gill, M.C. (2021) Irritable Bowel Syndrome: Questions and Answers for Effective Care. *American Family Physician*, **103**, 727-736.

- [48] Pasta, A., Formisano, E., Calabrese, F., Plaz Torres, M., Bodini, G., Marabotto, E., *et al.* (2024) Food Intolerances, Food Allergies and IBS: Lights and Shadows. *Nutrients*, **16**, Article 265. <https://doi.org/10.3390/nu16020265>
- [49] Ohlsson, B. (2022) Extraintestinal Manifestations in Irritable Bowel Syndrome: A Systematic Review. *Therapeutic Advances in Gastroenterology*, **15**. <https://doi.org/10.1177/17562848221114558>
- [50] Simren, M., Palsson, O.S. and Whitehead, W.E. (2017) Update on Rome IV Criteria for Colorectal Disorders: Implications for Clinical Practice. *Current Gastroenterology Reports*, **19**, Article No. 15. <https://doi.org/10.1007/s11894-017-0554-0>
- [51] Lacy, B.E., Mearin, F., Chang, L., Chey, W.D., Lembo, A.J., Simren, M., *et al.* (2016) Bowel Disorders. *Gastroenterology*, **150**, 1393-1407.e5. <https://doi.org/10.1053/j.gastro.2016.02.031>
- [52] Porwal, A., Bhagwat, G., Sawarkar, J. and Kamble, P. (2024) The Irritable Bowel Syndrome (IBS): Understanding Its Types, Prevalence, and Treatment Options. *World Journal of Advanced Research and Reviews*, **22**, 720-728. <https://doi.org/10.30574/wjarr.2024.22.1.1130>
- [53] Sperber, A.D. (2021) Review Article: Epidemiology of IBS and Other Bowel Disorders of Gut-Brain Interaction (DGBI). *Alimentary Pharmacology & Therapeutics*, **54**, S1-S11. <https://doi.org/10.1111/apt.16582>
- [54] Sasegbon, A. and Vasant, D.H. (2021) Understanding Racial Disparities in the Care of Patients with Irritable Bowel Syndrome: The Need for a Unified Approach. *Neurogastroenterology & Motility*, **33**, e14152. <https://doi.org/10.1111/nmo.14152>
- [55] Black, C.J., Ford, A.C., Thakur, E.R. and Sood, R. (2022) Prevalence and Pathophysiology of Irritable Bowel Syndrome: Impact of Sex and Gender. *Gastroenterology*, **162**, 752-763.
- [56] Hafiz, T.A., Alhemayed, T.S., Mandorah, R.H., Alshantqi, A.A., Almohaimed, R.A. and Noor, O.M. (2023) Irritable Bowel Syndrome: Prevalence and Determinants among Adults in the Makkah Region, Saudi Arabia. *Cureus*, **15**, e39568. <https://doi.org/10.7759/cureus.39568>
- [57] Collier, C.A., Salikhova, A., Sabir, S., Focerrada, S. and Raghavan, S.A. (2024) Crisis in the Gut: Navigating Gastrointestinal Challenges in Gulf War Illness with Bioengineering. *Military Medical Research*, **11**, Article No. 45. <https://doi.org/10.1186/s40779-024-00547-2>
- [58] Midvalley (2018) Symptoms and Treatment of Irritable Bowel Syndrome. <https://www.midvalleygi.com/blog/321672-symptoms-and-treatment-of-irritable-bowel-syndrome>
- [59] Andrews, C.N. and Storr, M. (2011) The Pathophysiology of Chronic Constipation. *Canadian Journal of Gastroenterology*, **25**, 16B-21B. <https://doi.org/10.1155/2011/715858>
- [60] Patel, S., Doerfler, B., Boutros, K., Ng, S., Manuel, M. and DeSimone, E. (2021) Review of Treatment Options for Irritable Bowel Syndrome with Constipation and Chronic Idiopathic Constipation. *International Journal of General Medicine*, **14**, 1457-1468. <https://doi.org/10.2147/ijgm.s274568>
- [61] Camacho-Díaz, B., Arenas-Ocampo, M., Osorio-Díaz, P., Jiménez-Aparicio, A., Alvarado-Jasso, G., Saavedra-Briones, E., *et al.* (2023) The Effects of Agave Fructans in a Functional Food Consumed by Patients with Irritable Bowel Syndrome with Constipation: A Randomized, Double-Blind, Placebo-Controlled Trial. *Nutrients*, **15**, Article 3526. <https://doi.org/10.3390/nu15163526>

- [62] Tack, J., Müller-Lissner, S., Stanghellini, V., Boeckxstaens, G., Kamm, M.A., Simren, M., *et al.* (2011) Diagnosis and Treatment of Chronic Constipation—A European Perspective. *Neurogastroenterology & Motility*, **23**, 697-710. <https://doi.org/10.1111/j.1365-2982.2011.01709.x>
- [63] Aoun, A., Maalouf, J., Khalil, S. and Khoury, V. (2021) The Role of Nutrition in the Treatment of Irritable Bowel Syndrome. *Family Medicine & Primary Care Review*, **23**, 495-500. <https://doi.org/10.5114/fmpcr.2021.108206>
- [64] Di Rosa, C., Altomare, A., Terrigno, V., Carbone, F., Tack, J., Cicala, M., *et al.* (2023) Constipation-Predominant Irritable Bowel Syndrome (IBS-C): Effects of Different Nutritional Patterns on Intestinal Dysbiosis and Symptoms. *Nutrients*, **15**, Article 1647. <https://doi.org/10.3390/nu15071647>
- [65] Altomare, A., Di Rosa, C., Imperia, E., Emerenziani, S., Cicala, M. and Guarino, M.P.L. (2021) Diarrhea Predominant-Irritable Bowel Syndrome (IBS-D): Effects of Different Nutritional Patterns on Intestinal Dysbiosis and Symptoms. *Nutrients*, **13**, Article 1506. <https://doi.org/10.3390/nu13051506>
- [66] Cangemi, D.J. and Lacy, B.E. (2019) Management of Irritable Bowel Syndrome with Diarrhea: A Review of Nonpharmacological and Pharmacological Interventions. *Therapeutic Advances in Gastroenterology*, **12**. <https://doi.org/10.1177/1756284819878950>
- [67] Jayasinghe, M., Karunanayake, V., Mohtashim, A., Caldera, D., Mendis, P., Prathiraja, O., *et al.* (2024) The Role of Diet in the Management of Irritable Bowel Syndrome: A Comprehensive Review. *Cureus*, **16**, e54244. <https://doi.org/10.7759/cureus.54244>
- [68] Soldi, S., Vasileiadis, S., Uggeri, F., Campanale, M.C., Morelli, L., Calanni, F., *et al.* (2015) Modulation of the Gut Microbiota Composition by Rifaximin in Non-Constipated Irritable Bowel Syndrome Patients: A Molecular Approach. *Clinical and Experimental Gastroenterology*, **8**, 309-325. <https://doi.org/10.2147/ceg.s89999>
- [69] Algera, J., Colomier, E. and Simrén, M. (2019) The Dietary Management of Patients with Irritable Bowel Syndrome: A Narrative Review of the Existing and Emerging Evidence. *Nutrients*, **11**, Article 2162. <https://doi.org/10.3390/nu11092162>
- [70] Radziszewska, M., Smarkusz-Zarzecka, J. and Ostrowska, L. (2023) Nutrition, Physical Activity and Supplementation in Irritable Bowel Syndrome. *Nutrients*, **15**, Article 3662. <https://doi.org/10.3390/nu15163662>
- [71] Kinsinger, S. (2017) Cognitive-behavioral Therapy for Patients with Irritable Bowel Syndrome: Current Insights. *Psychology Research and Behavior Management*, **10**, 231-237. <https://doi.org/10.2147/prbm.s120817>
- [72] Saha, L. (2014) Irritable Bowel Syndrome: Pathogenesis, Diagnosis, Treatment, and Evidence-Based Medicine. *World Journal of Gastroenterology*, **20**, 6759-6773. <https://doi.org/10.3748/wjg.v20.i22.6759>
- [73] Black, C.J., Yiannakou, Y., Guthrie, E., West, R., Houghton, L.A. and Ford, A.C. (2021) Longitudinal Follow-Up of a Novel Classification System for Irritable Bowel Syndrome: Natural History and Prognostic Value. *Alimentary Pharmacology & Therapeutics*, **53**, 1126-1137. <https://doi.org/10.1111/apt.16322>
- [74] Ford, A.C., Moayyedi, P., Chey, W.D., Harris, L.A., Lacy, B.E., Saito, Y.A., *et al.* (2018) American College of Gastroenterology Monograph on Management of Irritable Bowel Syndrome. *American Journal of Gastroenterology*, **113**, 1-18. <https://doi.org/10.1038/s41395-018-0084-x>
- [75] Vulpoi, R.A., Luca, M., Ciobanu, A., Olteanu, A., Bărboi, O., Iov, D., *et al.* (2023) The Potential Use of Artificial Intelligence in Irritable Bowel Syndrome Management. *Diagnostics*, **13**, Article 3336. <https://doi.org/10.3390/diagnostics13213336>

- [76] Cesario, A., D'Oria, M., Bove, F., Privitera, G., Boškoski, I., Pedicino, D., *et al.* (2021) Personalized Clinical Phenotyping through Systems Medicine and Artificial Intelligence. *Journal of Personalized Medicine*, **11**, Article 265. <https://doi.org/10.3390/jpm11040265>
- [77] Ford, A.C., Lacy, B.E. and Talley, N.J. (2017) Irritable Bowel Syndrome. *New England Journal of Medicine*, **376**, 2566-2578. <https://doi.org/10.1056/nejmra1607547>
- [78] Tsukanov, V.V., Vasyutin, A.V. and Tonkikh, J.L. (2021) Modern Aspects of the Management of Patients with Irritable Bowel Syndrome. *Meditinskiy sovet = Medical Council*, No. 5, 22-28. <https://doi.org/10.21518/2079-701x-2021-5-22-28>
- [79] Ban, Q., Liu, M., Ding, N., Chen, Y., Lin, Q., Zha, J., *et al.* (2022) Nutraceuticals for the Treatment of IBD: Current Progress and Future Directions. *Frontiers in Nutrition*, **9**, Article 794169. <https://doi.org/10.3389/fnut.2022.794169>
- [80] El-Salhy, M., Patcharatrakul, T. and Gonlachanvit, S. (2021) Fecal Microbiota Transplantation for Irritable Bowel Syndrome: An Intervention for the 21st Century. *World Journal of Gastroenterology*, **27**, 2921-2943. <https://doi.org/10.3748/wjg.v27.i22.2921>
- [81] Yu, X., Wu, Q., He, L. and Zheng, Y. (2023) Role of in Vitamin D in Irritable Bowel Syndrome. *World Journal of Clinical Cases*, **11**, 2677-2683. <https://doi.org/10.12998/wjcc.v11.i12.2677>
- [82] Aribi, M., Mennechet, F.J.D. and Touil-Boukoffa, C. (2023) Editorial: The Role of Vitamin D as an Immunomodulator. *Frontiers in Immunology*, **14**, Article 1186635. <https://doi.org/10.3389/fimmu.2023.1186635>
- [83] Rinninella, E., Mele, M.C., Raoul, P., Cintoni, M. and Gasbarrini, A. (2021) Vitamin D and Colorectal Cancer: Chemopreventive Perspectives through the Gut Microbiota and the Immune System. *BioFactors*, **48**, 285-293. <https://doi.org/10.1002/biof.1786>
- [84] Williams, C.E., Williams, E.A. and Corfe, B.M. (2020) Effect of Vitamin D Supplementation on Irritable Bowel Syndrome Symptom Severity and Quality of Life. *Proceedings of the Nutrition Society*, **79**, E14. <https://doi.org/10.1017/s0029665119001356>
- [85] Williams, C.E., Williams, E.A. and Corfe, B.M. (2021) Vitamin D Supplementation in People with IBS Has No Effect on Symptom Severity and Quality of Life: Results of a Randomised Controlled Trial. *European Journal of Nutrition*, **61**, 299-308. <https://doi.org/10.1007/s00394-021-02633-w>
- [86] Williams, C.E. (2023) Vitamin D and Symptom Severity in Individuals with Irritable Bowel Syndrome. Master's Thesis, University of Sheffield.
- [87] Linsalata, M., Riezzo, G., Orlando, A., D'Attoma, B., Prospero, L., Tutino, V., *et al.* (2021) The Relationship between Low Serum Vitamin D Levels and Altered Intestinal Barrier Function in Patients with IBS Diarrhoea Undergoing a Long-Term Low-Fodmap Diet: Novel Observations from a Clinical Trial. *Nutrients*, **13**, Article 1011. <https://doi.org/10.3390/nu13031011>
- [88] Abuelazm, M., Muhammad, S., Gamal, M., Labieb, F., Amin, M.A., Abdelazeem, B., *et al.* (2022) The Effect of Vitamin D Supplementation on the Severity of Symptoms and the Quality of Life in Irritable Bowel Syndrome Patients: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Nutrients*, **14**, Article 2618. <https://doi.org/10.3390/nu14132618>
- [89] Matthews, S.W., Heitkemper, M.M. and Kamp, K. (2021) Early Evidence Indicates Vitamin D Improves Symptoms of Irritable Bowel Syndrome: Nursing Implications and Future Research Opportunities. *Gastroenterology Nursing*, **44**, 426-436. <https://doi.org/10.1097/sga.0000000000000634>

- [90] Yan, C., Hu, C., Chen, X., Jia, X., Zhu, Z., Ye, D., *et al.* (2023) Vitamin D Improves Irritable Bowel Syndrome Symptoms: A Meta-Analysis. *Heliyon*, **9**, e16437. <https://doi.org/10.1016/j.heliyon.2023.e16437>
- [91] Chong, R.I.H., Yaow, C.Y.L., Loh, C.Y.L., Teoh, S.E., Masuda, Y., Ng, W.K., *et al.* (2022) Vitamin D Supplementation for Irritable Bowel Syndrome: A Systematic Review and Meta-Analysis. *Journal of Gastroenterology and Hepatology*, **37**, 993-1003. <https://doi.org/10.1111/jgh.15852>
- [92] Elgar, K. (2022) Vitamin D: A Review of Clinical Use and Efficacy. *Nutritional Medicine Journal*, **1**, 52-78.
- [93] Agrawal, M., Spencer, E.A., Colombel, J. and Ungaro, R.C. (2021) Approach to the Management of Recently Diagnosed Inflammatory Bowel Disease Patients: A User's Guide for Adult and Pediatric Gastroenterologists. *Gastroenterology*, **161**, 47-65. <https://doi.org/10.1053/j.gastro.2021.04.063>
- [94] Roncoroni, L., Gori, R., Elli, L., Tontini, G.E., Doneda, L., Norsa, L., *et al.* (2022) Nutrition in Patients with Inflammatory Bowel Diseases: A Narrative Review. *Nutrients*, **14**, Article 751. <https://doi.org/10.3390/nu14040751>
- [95] Mishra, A., Chandel, A.K.S., Bhalani, D.V. and Shrivastava, R. (2021) Importance of Dietary Supplements to the Health. *Current Nutrition & Food Science*, **17**, 583-600. <https://doi.org/10.2174/1573401316999200901111519>
- [96] Durkin, L.A., Childs, C.E. and Calder, P.C. (2021) Omega-3 Polyunsaturated Fatty Acids and the Intestinal Epithelium—A Review. *Foods*, **10**, Article 199. <https://doi.org/10.3390/foods10010199>
- [97] EFSA (2024) Dietary Reference Values for Vitamin D. <https://www.efsa.europa.eu/en/efsajournal/pub/4547>
- [98] (2024) SACN Vitamin D and Health Report. <https://www.gov.uk/government/publications/sacn-vitamin-d-and-health-report>
- [99] Corsello, A., Spolidoro, G.C.I., Milani, G.P. and Agostoni, C. (2023) Vitamin D in Pediatric Age: Current Evidence, Recommendations, and Misunderstandings. *Frontiers in Medicine*, **10**, Article 1107855. <https://doi.org/10.3389/fmed.2023.1107855>
- [100] Abbasnezhad, A., Amani, R., Hajiani, E., Alavinejad, P., Cheraghian, B. and Ghadiri, A. (2016) Effect of Vitamin D on Gastrointestinal Symptoms and Health-Related Quality of Life in Irritable Bowel Syndrome Patients: A Randomized Double-Blind Clinical Trial. *Neurogastroenterology & Motility*, **28**, 1533-1544. <https://doi.org/10.1111/nmo.12851>
- [101] Hekmatdoost, A., Jalili, M., Vahedi, H. and Poustchi, H. (2019) Effects of Vitamin D Supplementation in Patients with Irritable Bowel Syndrome: A Randomized, Double-Blind, Placebo-Controlled Clinical Trial. *International Journal of Preventive Medicine*, **10**, 16. https://doi.org/10.4103/ijpvm.ijpvm_512_17
- [102] Battistini, C., Ballan, R., Herkenhoff, M.E., Saad, S.M.I. and Sun, J. (2020) Vitamin D Modulates Intestinal Microbiota in Inflammatory Bowel Diseases. *International Journal of Molecular Sciences*, **22**, Article 362. <https://doi.org/10.3390/ijms22010362>
- [103] Barbalho, S.M., Goulart, R.d.A., Araújo, A.C., Guiguer, É.L. and Bechara, M.D. (2019) Irritable Bowel Syndrome: A Review of the General Aspects and the Potential Role of Vitamin D. *Expert Review of Gastroenterology & Hepatology*, **13**, 345-359. <https://doi.org/10.1080/17474124.2019.1570137>
- [104] Zielińska, A., Sobolewska-Włodarczyk, A., Wiśniewska-Jarosińska, M., Gąsiorowska, A., Fichna, J. and Sałaga, M. (2021) The 25(OH)D3, but Not 1,25(OH)2D3 Levels Are Elevated in IBD Patients Regardless of Vitamin D Supplementation and Do Not

- Associate with Pain Severity or Frequency. *Pharmaceuticals*, **14**, Article 284. <https://doi.org/10.3390/ph14030284>
- [105] Dominguez, L.J., Farruggia, M., Veronese, N. and Barbagallo, M. (2021) Vitamin D Sources, Metabolism, and Deficiency: Available Compounds and Guidelines for Its Treatment. *Metabolites*, **11**, Article 255. <https://doi.org/10.3390/metabo11040255>
- [106] Webb, A.R., Alghamdi, R., Kift, R. and Rhodes, L.E. (2021) 100 YEARS of VITAMIN D: Dose-Response for Change in 25-Hydroxyvitamin D after UV Exposure: Outcome of a Systematic Review. *Endocrine Connections*, **10**, R248-R266. <https://doi.org/10.1530/ec-21-0308>
- [107] Mendes, M.M., Hart, K.H., Williams, E.L., Mendis, J., Lanham-New, S.A. and Botelho, P.B. (2021) Vitamin D Supplementation and Sunlight Exposure on Serum Vitamin D Concentrations in 2 Parallel, Double-Blind, Randomized, Placebo-Controlled Trials. *The Journal of Nutrition*, **151**, 3137-3150. <https://doi.org/10.1093/jn/nxab209>
- [108] Głabska, D., Kołota, A., Lachowicz, K., Skolmowska, D., Stachoń, M. and Guzek, D. (2021) Vitamin D Supplementation and Mental Health in Inflammatory Bowel Diseases and Irritable Bowel Syndrome Patients: A Systematic Review. *Nutrients*, **13**, Article 3662. <https://doi.org/10.3390/nu13103662>
- [109] Pagnini, C., Di Paolo, M.C., Graziani, M.G. and Delle Fave, G. (2021) Probiotics and Vitamin D/Vitamin D Receptor Pathway Interaction: Potential Therapeutic Implications in Inflammatory Bowel Disease. *Frontiers in Pharmacology*, **12**, Article 747856. <https://doi.org/10.3389/fphar.2021.747856>
- [110] Zeraattalab-Motlagh, S., Ranjbar, M., Mohammadi, H. and Adibi, P. (2024) Nutritional Interventions in Adult Patients with Irritable Bowel Syndrome: An Umbrella Review of Systematic Reviews and Meta-Analyses of Randomized Clinical Trials. *Nutrition Reviews*. <https://doi.org/10.1093/nutrit/nuae107>
- [111] Vernia, F., Valvano, M., Longo, S., Cesaro, N., Viscido, A. and Latella, G. (2022) Vitamin D in Inflammatory Bowel Diseases. Mechanisms of Action and Therapeutic Implications. *Nutrients*, **14**, Article 269. <https://doi.org/10.3390/nu14020269>
- [112] Wang, J., Mei, L., Hao, Y., Xu, Y., Yang, Q., Dai, Z., *et al.* (2024) Contemporary Perspectives on the Role of Vitamin D in Enhancing Gut Health and Its Implications for Preventing and Managing Intestinal Diseases. *Nutrients*, **16**, Article 2352. <https://doi.org/10.3390/nu16142352>
- [113] Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D. and Moher, D. (2021) The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews. *BMJ*, **372**, n71.
- [114] Brown, K.M., Elliott, S.J., Leatherdale, S.T. and Robertson-Wilson, J. (2015) Searching for Rigour in the Reporting of Mixed Methods Population Health Research: A Methodological Review. *Health Education Research*, **30**, 811-839. <https://doi.org/10.1093/her/cyv046>