FLANCZEWSKI, Sebastian, GAJEK-FLANCZEWSKA, Wiktoria, WALCZAK, Agata, WIRKIJOWSKI, Jakub, NIEGOWSKA, Wiktoria, WOŹNIAK, Paulina, KIDACKI, Kajetan, WIKLIŃSKA, Agata, ŚLIWIŃSKA, Martyna, WÓJTOWICZ, Katarzyna, JAROŃ, Aleksandra and PIĄTKOWSKA, Karolina. Clinical management of constipation – the role of physical activity - systematic review. Quality in Sport. 2024;31:55135. eISSN 2450-3118.
https://dx.doi.org/10.12775/QS.2024.31.55135
https://apcz.umk.pl/QS/article/view/55135

The journal has been 20 points in the Ministry of Higher Education and Science of Poland parametric evaluation. Annex to the announcement of the Minister of Higher Education and Science of 05.01.2024. No. 32553.
Has a Journal's Unique Identifier: 201398. Scientific disciplines assig589 ned: Economics and finance (Field of social sciences); Management and Quality Sciences (Field of social sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 r. Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398.
Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).

The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 12.09.2024. Revised: 07.11.2024. Accepted: 08.11.2024. Published: 12.11.2024.

Clinical management of constipation – the role of physical activity - systematic review

Wiktoria Gajek-Flanczewska
Central Clinical Hospital, Banacha 1A, 02-097 Warsaw, Poland
https://orcid.org/0009-0004-8875-433X
wiktoria.gajek@onet.eu

Sebastian Flanczewski
Central Clinical Hospital, Banacha 1A, 02-097 Warsaw, Poland
https://orcid.org/0009-0006-8461-2806
flanczewskis@gmail.com

Agata Walczak
National Medical Institute of the Ministry of the Interior and Administration, Wołoska 137, 02-507, Warsaw, Poland
https://orcid.org/0009-0004-7023-634X
walag2410@gmail.com

Jakub Wirkijowski
Independent Public Clinical Hospital of Prof. W. Orlowski, Czerniakowska 231, 00-401, Warsaw, Poland
https://orcid.org/0009-0007-9882-9341
k.wirkijowski0@gmail.com

Wiktoria Niegowska
Independent Public Clinical Hospital of Prof. W. Orlowski, Czerniakowska 231, 00-401, Warsaw, Poland
https://orcid.org/0009-0001-9843-8048
niegowskawiktoria@gmail.com

Paulina Woźniak
Medical University of Warsaw, Żwirki i Wigury 61, 02-091 Warsaw, Poland
https://orcid.org/0009-0006-9626-1062
paulinawoz777@gmail.com

Kajetan Kidacki
Medical University of Warsaw, Żwirki i Wigury 61, 02-091 Warsaw, Poland
https://orcid.org/0009-0005-5680-2947
kajetan.kidacki@gmail.com

Agata Wiklińska
Praski Hospital of the Transfiguration of the Lord, al. "Solidarności" 67, 03-401 Warsaw, Poland
https://orcid.org/0009-0008-8758-5860
agata.wiklinska@gmail.com

Martyna Śliwińska
Military Institute of Medicine – National Research Institute, Szaserów 128, 04-141 Warsaw, Poland
https://orcid.org/0009-0008-2757-5660
sliwinskamartyna29@gmail.com

Katarzyna Wójtowicz
Central Clinical Hospital, Banacha 1A, 02-097 Warsaw, Poland
https://orcid.org/0009-0009-3914-7804
wojtowicz.katarzyna14@gmail.com

Aleksandra Jaroń
Praski Hospital of the Transfiguration of the Lord, al. "Solidarności" 67, 03-401 Warsaw, Poland
https://orcid.org/0009-0003-7877-5308
olajaron@o2.pl

Karolina Piątkowska
Health Care Complex of the District Hospital in Sochaczew, Batalionów Chłopskich 3/7
96-500 Sochaczew, Poland
https://orcid.org/0009-0000-6750-7517
karolina.piatkowska18@gmail.com

ABSTRACT:
Constipation is a prevalent gastrointestinal disorder that affects a significant portion of the global population, yet its management remains challenging due to its complex etiology. This review explores the potential benefits and mechanisms of physical activity in alleviating constipation symptoms. We examined recent studies on the physiological effects of various exercise types and intensities on bowel movements, gastrointestinal blood flow, and microbiome composition. Our findings suggest that aerobic exercise enhances colonic motility and accelerates gastrointestinal transit, though the effects vary depending on exercise duration and intensity. While light to moderate physical activity (less than 60 minutes) appears beneficial, prolonged or intense exercise may inhibit motility and exacerbate symptoms. Additionally, exercise-induced changes in the gut microbiome and blood flow dynamics were observed, influencing stool consistency and colonic function. However, the interplay between diet, hydration, and physical activity is crucial, as adequate dietary fiber and hydration are essential for optimizing exercise's impact on constipation. Although evidence supports the role of physical activity in managing constipation, further research is needed to clarify the most effective exercise regimens and their integration with dietary and lifestyle modifications.

KEYWORDS: CONSTIPATION, SPORT, PHYSICAL ACTIVITY

INTRODUCTION

Common phrase "sport is health" is associated with benefits to every aspect of human life. This review describes potential benefits of physical activity on constipation.

No one is undermining its obvious asset, but we came with a simple question: how does it really affect our guts? When looking at a playground with children running around, we wonder how it is possible that 1 in 10 will have a problem with constipation. Patients often hear to move more and eat pickled foods to avoid hard stool. But which one is an actual cure? Constipation, a type of functional bowel disorder, is one of the most prevalent chronic gastrointestinal diseases, impacting between 0.7% and 29.6% of individuals in both developed and developing countries [1]. The prevalence of constipation appears to be significantly influenced by factors like gender (with the ratio of men to women ranging from 1:1.22 to 1:4.56. [2]), geographic region, age, educational level and race.

Traditionally, constipation describes infrequent bowel movements or hard stools. However, the condition is diverse, with some patients experiencing various symptoms such as less frequent bowel movements, straining, hard stools, the feeling of incomplete evacuation, include infrequent, painful bowel movements, hard stools, fecal incontinence, and abdominal pain, a sensation of blockage in the anus, or the need to use manual assistance or positioning to facilitate defecation [3,4].

While not directly associated with mortality, mental well-being, physical health and social functioning are diminished when patients suffer from constipation [5,6].
There are various treatments for constipation, such as medications, lifestyle modifications (like a balanced diet, increased fluid intake, and proper bowel habits), acupuncture, electro-acupuncture, transanal irrigation [7] biofeedback, and surgery [8]. It seems to be one of the most simple conditions to treat, yet is most challenging to this day. Due to the complex causes and mechanisms of constipation, many existing treatments are not effective for everyone. Current guidelines recommend fiber supplementation as the primary treatment for chronic idiopathic constipation (CIC). However, up to 50% of patients either do not respond to or become dissatisfied with fiber as a treatment approach [9].
We provided an updated overview of the positive and negative effects of physical activity on the gastrointestinal tract. Our discussion aimed to explore recent findings on how various types and intensities of exercise have a measurable effect on the physiological bowel movement.

MATERIALS AND METHODS

Relevant papers were searched in PubMed, Embase, and Google Scholar, UpToDate using keywords such as constipation, functional constipation, chronic constipation, idiopathic constipation, physical activity, sport and exercise. The reference lists of the articles found were also reviewed to identify additional studies, most based on title and abstract. After analysing the abstracts, 46 scientific articles were selected and read.

PHYSIOLOGY

To start assessing an up-to-date knowledge about constipation, firstly we need to summarise the physiological aspect of the following disorder. Serotonin stimulates receptors that transmit signals through the myenteric nerve plexus, triggering a wave of intestinal smooth muscle contractions that move the contents of the lumen. The primary mechanism for propulsive motility involves mass movements, which occur several times a day and ultimately result in defecation.

MECHANISM

Our results suggest that aerobic exercise can help relieve constipation symptoms. The underlying mechanisms are not well understood, but several factors have been suggested, including enhanced colonic motility, reduced blood flow to the gut, biomechanical bouncing of the intestines during running, compression of the colon by abdominal muscles, and increased fibre intake due to higher energy expenditure [10,13]. Running is connected with mechanical bouncing where the frequency of gastrointestinal symptoms is twice as high due to up and down movements in comparison with swimming or cycling. An upright posture, movement of the colonic contents, and the influence of gravity may all contribute to moving stool into the rectum and prompting defecation. However, this does not explain the evident effects of cycling, where the torso remains stationary on an exercise bike [14]. Research shows light physical activity can reduce abdominal distension [15,16] and ease bloating [16]. Enhanced colonic motility, speeds up gastrointestinal transit and stimulates the abdominal muscles, thereby aiding the movement of stool into the rectum [17-23].

GASTROINTESTINAL BLOOD FLOW

During exercise, blood is primarily redirected to the skin and active muscles, reducing the blood supply to the gastrointestinal tract. Although it seems difficult to imagine, the reduction of blood flow to guts accelerates bowel movement. Ischemic damage has been suggested also as a potential cause of gastrointestinal bleeding during and after exercise [10].

It has been found that splanchnic blood flow decreased by 60–70% in humans exercising at 70% of their maximal oxygen consumption ($\dot{V}O_2max$) [25]. At peak exercise intensity, splanchnic blood flow can be reduced by approximately 80% [11]. Earlier reviews have concentrated on the effects of exercise stress on splanchnic blood flow and the resulting intestinal ischemia and symptoms, cytokine responses, as well as gastrointestinal motility. Moreover, it remains unclear whether the physiological changes in the gastrointestinal tract caused by acute exercise stress lead to sudden shifts in the total bacterial abundance and diversity of the intestinal microbiome. The most significant exercise-induced endotoxemia has been observed following extreme endurance activities [12].

DURATION OF ACTIVITY

The WHO (The World Health Organization) recommends that adults engage in at least 150 to 300 minutes of moderate aerobic activity per week (or an equivalent amount of vigorous activity), and that children and adolescents participate in an average of 60 minutes of moderate aerobic activity daily [24]. From a physiological point of view exercise intensity should be chosen carefully, as gastrointestinal symptoms are common during activities like running and have been suggested as key factors that can limit performance [12].

Short-duration exercise sessions of low to moderate intensity (less than 60 minutes) seem to enhance gastrointestinal motility, whereas longer and more intense exercise (up to 90 minutes) might inhibit it. Engaging in aerobic exercise for at least 140 minutes per week significantly alleviated constipation symptoms [26-30]. Only one study reported improvements in constipation symptoms with a shorter exercise duration, where participants walked for 100 minutes per week [31]. Aerobic exercises lasting less than 140 minutes per week appeared to have no impact on improving constipation symptoms [32]. It is suggested that patients in hospitals where proper physical activity is insufficient, were asked to spend time on walking around the ward, which also had evident influence on bowel movement compared to stay-in-bed subjects.

PROFESSIONAL ATHLETES

The impact of exercise on gastric emptying has been evaluated in several studies. When searching for evidence of constipation in athletes, we observed that recreational 10-21-42 km runners did not report such symptoms, on contrary to 24-hours continuous ultra-marathon athletes, who frequently experience gastrointestinal symptoms, especially nausea or urge to regurgitate and diarrhea and the topic of ours - constipation [12]. Generally, strenuous exercise in trained individuals tends to inhibit gastric emptying rather than increasing. Stool form was found to be correlated with pain perception and levels of anxiety which is difficult to measure independently in athletes [7]. This proves that there is no simple correlation between doing any kind of sport and experiencing no constipation at all.

Gastrointestinal issues are reported in approximately 30% of long-distance runners including: abdominal cramping, frequent bowel movements, increased blood loss, and occasional bloody diarrhea [14]. This may sound like irritable bowel syndrome and yet happens to prior healthy individuals and is transient. Nocturnal exercise compared to exercise performed during the day caused more pronounced gastrointestinal functional disruptions and symptoms, along with a significant increase in cortisol levels. In the following study examining stress hormone circulation in endurance runners, gastrointestinal incidence like watery stools or urge to defecate was more likely associated with prolonged exercise and reduced water intake, which could cause discomfort [34]. Among the various factors proposed to affect large bowel function, diet is the most significant.

Dehydration also heightens gastrointestinal distress symptoms, indicating that inadequate fluid replacement disrupts gut function and may influence the gut microbiota [35]. The colon plays a crucial role in regulating intestinal fluid and electrolyte balance, reabsorbing approximately 1–2 liters of fluid daily.

Prosecretory drugs can enhance the intestinal luminal fluid and electrolyte content enough to overwhelm this process, leading to changes in stool consistency and a reduction in colonic transit time [7]. Hence there is no evidence that increasing fluid intake effectively treats chronic idiopathic constipation (CIC) unless dehydration is present [36].

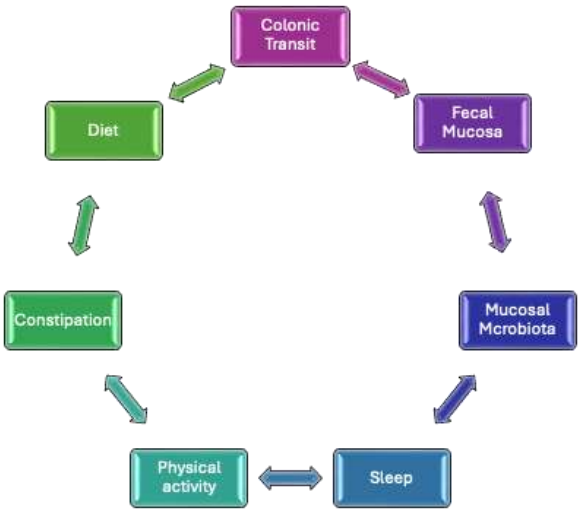

Figure 1. Chain of connections.

MICROBIOME

Diet and exercise influence the composition and function of the gut microbiome by altering substrate availability and causing physiological changes in the gastrointestinal environment [11,37]. Cardiorespiratory exercise leads to immediate alterations in gut microbiota composition, while resistance exercise shows no impact [38]. There are several alterations happening to the mucosal microbiota happening when delayed small intestine transit occurs. Some research suggests that an abnormal gut microbiota composition, known as dysbiosis, may play a role in the development of chronic idiopathic constipation. It is still uncertain whether the physiological changes in the gastrointestinal tract triggered by acute exercise stress result in immediate alterations in the overall abundance and diversity of the intestinal microbiome.

Alterations in the colonic microbiota can enhance bile acid metabolism, increase methane production, and impact epithelial function, all of which can influence colonic motility and fluid secretion, leading to constipation. While the composition of the overall colonic mucosal microbiota has been strongly linked to constipation status, the fecal microbiota is connected to both colonic transit and methane production in the breath [39,40].

Patients with chronic idiopathic constipation have been found to have lower levels of "beneficial" bacteria, such as bifidobacteria, and higher levels of "pathogenic" bacteria, such as clostridia [9]. Fiber supplementation significantly reduced clostridia counts compared to a placebo, showing a moderate effect size. However, it remains unclear whether these beneficial changes in gut microbiota composition can lead to alterations in gastrointestinal transit that might improve constipation symptoms. Recent studies have demonstrated that a high protein intake in athletes' without sufficient dietary fiber not only negates the positive effects of exercise on gut microbiota but also significantly reduces the proportion of beneficial bacteria [41].

On the other hand, evidence shows that nutrition, high levels of physical activity, and sleep hygiene can greatly influence sleep quality. Positive correlation was found between constipation and excessive daytime sleepiness [37].

Similarly, disrupted or insufficient sleep is linked to the onset of dysbiosis, potentially due to the activation of the hypothalamic-pituitary-adrenal axis. In the same manner, gut experiencing dysbiosis can generate free radicals and inflammatory cytokines, therefore leading to poorer sleep quality. And the circle stays closed.

DIET

S. A. Bingham and J. H. Cummings from University of Cambridge and Medical Research Council studied the impact of physical activity training program on large bowel function while participants followed a consistent diet [14]. Despite all improvements consistent with what is generally anticipated from increased physical exercise, there was no overall change in average intestinal transit time. Neither mild activity nor more intense exercise had a consistent impact on bowel movements. Exercise may indeed impact the colon compared to complete inactivity, but the current study suggests that variations in physical activity within the typical range of daily life have no significant effect. As a result, physical activity alone, without accompanying dietary changes, does not seem to have significant physiological effects on colonic function [10].

Nevertheless, a simple dietary change could lead to an average increase of 100 grams in fecal weight and a reduction in transit time by 30 hours.

Training, meal composition, adequate fiber intake, proper hydration are inevitable when athletes plan strenuous exercise.

GENDER

Research indicates that females are two to three times more likely to experience chronic idiopathic constipation compared to males. An obstetric and gynecological history is also crucial when evaluating constipation symptoms in women as (PID) pelvic floor dysfunction is associated with constipation beforehand [36]. Some studies have reported that PID may become the reason why women avoid physical activity.

Elevated estrogen levels during the luteal phase of the menstrual cycle are linked to prolonged intestinal transit time, and conditions associated with higher estrogen plasma levels have been found to correlate with reduced bowel movement frequency [10,42]. Therefore, women who engaged in daily physical activity had a lower prevalence of constipation - 17% compared to 22% of non-exercisers [43]. Also, women were more likely than men to experience gastrointestinal symptoms related to exercise [12]. The decreasing estrogen plasma levels after menopause might explain the inverse relationship between age and low bowel movement frequency in women. On the other hand, women taking part in different studies were asked to evaluate their consumption of dietary fiber intake, and the more physical activity they reported to have, the better diet they tried to maintain. Another conclusion that popped up during evaluation of differences was that the older the subject, the bigger probability of using laxatives, as a prophylactic tool of having less firm stool.

CHILDREN

Most studies do not report differences in prevalence between boys and girls as in adults or find any correlations with socio-economic factors.

Functional constipation is the most common type of constipation in children, accounting for 95% of cases, with the highest rate of such disorder happening at the time of toilet training[44].

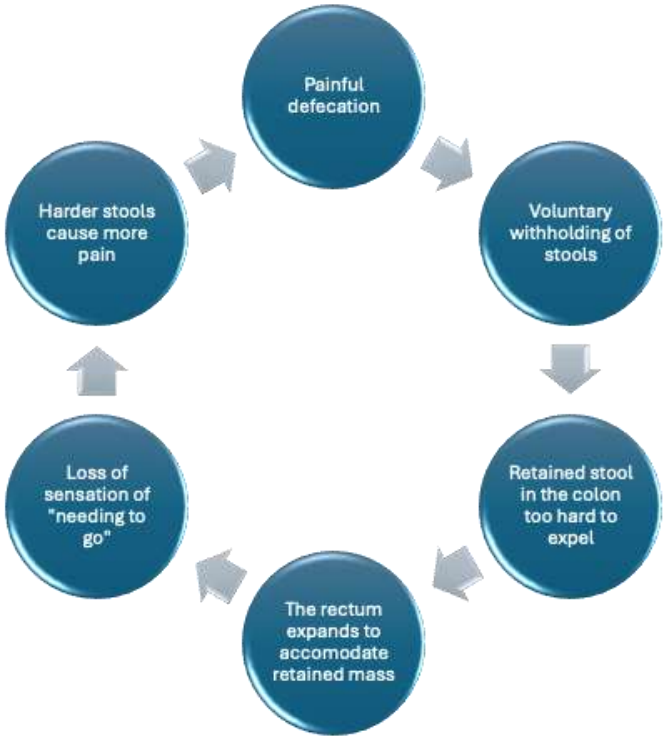

Figure 2. Functional constipation - vicious circle.

Psychological factors, including emotional stress, are likely to influence colonic and rectal functions through the brain-gut axis, potentially leading to constipation. Children who are deeply engaged in play, occupied with other activities, or in a hurry may not take the time to use the bathroom. If the urge to defecate is repeatedly disregarded, the brain may become less sensitive to future defecation signals.

Research suggests a low fiber diet and reduced physical activity as cofactors. Medications have been demonstrated to be more effective than behavioural changes alone in treating constipation [45].
Regular physical activity can be recommended, although its role in treating constipation is unclear. To this day, no randomized studies have assessed the impact of increased physical activity on childhood constipation [46].

CONCLUSION

Physical activity generally acts as a broad term covering various forms of exercise, each of which may have distinct effects on the body. As an example, increased energy expenditure raises the need for energy intake, which can impact the overall dietary fiber consumption. Therefore, combining a high-fiber diet with a moderate level of physical activity, good quality of sleep is likely to result in the lowest risk of constipation. It is important to highlight that no perfect study has been conducted yet, because constipation is an underestimated problem often not treated due to lack of knowledge of how significant it is. Only a small percentage of individuals experiencing constipation seek medical advice. Pediatric patients are proof that functional constipation sometimes is resistant to physical activity, and more precise steps are needed for treatment.
There is a shortage of direct evidence to reach firm conclusions. It is crucial to educate and treat patients in a manner that encourages comprehensive lifestyle changes. Although the preventive effects of physical activity are still uncertain, it is evident that physical activity is not harmful to patients, even considering the responses triggered by acute exercise.
Current guidelines are aiming to determine the optimal levels and types of a healthy diet and suitable physical activity, as well as how to integrate these different lifestyle modifications to achieve the most effective outcomes in preventing constipation.

DISCLOSURE

Author`s contribution:
Conceptualization: Wiktoria Gajek-Flanczewska, Sebastian Flanczewski
Methodology: Paulina Woźniak, Aleksandra Jaroń
Software: Agata Wiklińska, Kajetan Kidacki
Check: Katarzyna Wójtowicz, Wiktoria Niegowska
Formal analysis: Karolina Piątkowska, Jakub Wirkijowski
Investigation: Agata Wiklińska, Martyna Śliwińska
Resources: Wiktoria Gajek-Flanczewska, Sebastian Flanczewski
Data curation: Paulina Woźniak, Kajetan Kidacki
Writing - rough preparation: Sebastian Flanczewski, Agata Walczak
Writing - review and editing: Aleksandra Jaroń, Karolina Piątkowska
Visualization: Wiktoria Gajek-Flanczewska, Agata Walczak
Supervision: Martyna Śliwińska, Katarzyna Wójtowicz
Project administration: Wiktoria Niegowska, Jakub Wirkijowski
All authors have read and agreed with the published version of the manuscript.
Funding Statement: The study did not receive special funding.
Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.
Data Availability Statement: Not applicable.
Conflict of Interest Statement: There is no conflict of interest for the authors.
All authors have read and agreed with the published version of the manuscript.
Funding Statement: The study did not receive funding.
Institutional Review Board Statement: Not applicable.
Informed Consent Statement: Not applicable.
Data Availability Statement: Not applicable.
Conflict of Interest Statement: The authors declare no conflicts of interest.
Acknowledgements: Not applicable.

REFERENCES

1. Gao R, Tao Y, Zhou C, et al. Exercise Therapy in Patients with constipation: a Systematic Review and meta-analysis of Randomized Controlled Trials. Scandinavian Journal of Gastroenterology. 2019;54(2):169-177. doi:https://doi.org/10.1080/00365521.2019.1568544
2. Chu H, Zhong L, Li H, Zhang X, Zhang J, Hou X. Epidemiology Characteristics of Constipation for General Population, Pediatric Population, and Elderly Population in China. Gastroenterology Research and Practice. 2014;2014:1-11. doi:https://doi.org/10.1155/2014/532734 3.
Lacy BE, Mearin F, Chang L, et al. Bowel Disorders. Gastroenterology. 2016;150(6):1393-1407.e5. doi:https://doi.org/10.1053/j.gastro.2016.02.031
4. Kim SJ. Diet, Physical Activity, and Chronic Constipation: Unveiling the Combined Effects for Better Treatment Strategies. Journal of Neurogastroenterology and Motility. 2024;30(3):255-256. doi:https://doi.org/10.5056/jnm24085
5. Belsey J, Greenfield S, Candy D, Geraint M. Systematic review: impact of constipation on quality of life in adults and children. Alimentary Pharmacology & Therapeutics. 2010;31(9). doi:https://doi.org/10.1111/j.1365-2036.2010.04273.x
6. Heidelbaugh JJ, Stelwagon M, Miller SA, Shea EP, Chey WD. The Spectrum of Constipation-Predominant Irritable Bowel Syndrome and Chronic Idiopathic Constipation: US Survey Assessing Symptoms, Care Seeking, and Disease Burden. American Journal of Gastroenterology. 2015;110(4):580-587. doi:https://doi.org/10.1038/ajg.2015.67
7. Thomas RH, Luthin DR. Current and Emerging Treatments for Irritable Bowel Syndrome with Constipation and Chronic Idiopathic Constipation: Focus on Prosecretory Agents. Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy. 2015;35(6):613-630. doi:https://doi.org/10.1002/phar.1594
8. Kuizenga-Wessel S, Koppen IJN, Zwager LW, Di Lorenzo C, de Jong JR, Benninga MA. Surgical management of children with intractable functional constipation; experience of a single tertiary children's hospital. Neurogastroenterology & Motility. 2016;29(5):e13005. doi:https://doi.org/10.1111/nmo.13005
9. Christodoulides S, Dimidi E, Fragkos KC, Farmer AD, Whelan K, Scott SM. Systematic review with meta-analysis: effect of fibre supplementation on chronic idiopathic constipation in adults. Alimentary Pharmacology & Therapeutics. 2016;44(2):103-116. doi:https://doi.org/10.1111/apt.13662

10. Oettle GJ. Effect of moderate exercise on bowel habit. Gut. 1991;32(8):941-944. doi:https://doi.org/10.1136/gut.32.8.941
11. Hughes RL, Holscher HD. Fueling Gut Microbes: A Review of the Interaction between Diet, Exercise, and the Gut Microbiota in Athletes. Advances in Nutrition (Bethesda, Md). 2021;12(6):nmab077. doi:https://doi.org/10.1093/advances/nmab077
12. Costa RJS, Snipe RMJ, Kitic CM, Gibson PR. Systematic review: exercise-induced gastrointestinal syndrome-implications for health and intestinal disease. Alimentary Pharmacology & Therapeutics. 2017;46(3):246-265. doi:https://doi.org/10.1111/apt.14157
13. Koffler KH, Menkes A, Redmond RA, Whitehead WE, Pratley RE, Hurley BF. Strength training accelerates gastrointestinal transit in middle-aged and older men. Medicine and Science in Sports and Exercise. 1992;24(4):415???419-415???419. doi:https://doi.org/10.1249/00005768-199204000-00004
14. Bingham SA, Cummings JH. Effect of exercise and physical fitness on large intestinal function. Gastroenterology. 1989;97(6):1389-1399. doi:https://doi.org/10.1016/0016-5085(89)90381-8
15. Dainese R, Serra J, Azpiroz F, Malagelada Juan-R. Effects of physical activity on intestinal gas transit and evacuation in healthy subjects. The American Journal of Medicine. 2004;116(8):536-539. doi:https://doi.org/10.1016/j.amjmed.2003.12.018
16. Villoria A, Serra J, Azpiroz F, Malagelada Juan-R. Physical activity and intestinal gas clearance in patients with bloating. The American Journal of Gastroenterology. 2006;101(11):2552-2557. doi:https://doi.org/10.1111/j.1572-0241.2006.00873.x
17. Chey WD, Rai J. Exercise and IBS: No Pain, No Gain. Gastroenterology. 2011;141(5):1941-1943. doi:https://doi.org/10.1053/j.gastro.2011.09.030
18. Neufer PD, Young AJ, Sawka MN. Gastric emptying during walking and running: effects of varied exercise intensity. European Journal of Applied Physiology and Occupational Physiology. 1989;58(4):440-445. doi:https://doi.org/10.1007/BF00643522
19. Strid H, Simrén M, Störsrud S, Stotzer PO, Sadik R. Effect of heavy exercise on gastrointestinal transit in endurance athletes. Scandinavian Journal of Gastroenterology. 2011;46(6):673-677. doi:https://doi.org/10.3109/00365521.2011.558110
20. Johannesson E, Simrén M, Strid H, Bajor A, Sadik R. Physical Activity Improves Symptoms in Irritable Bowel Syndrome: A Randomized Controlled Trial. The American Journal of Gastroenterology. 2011;106(5):915-922. doi:https://doi.org/10.1038/ajg.2010.480
21. Østgaard H, Hausken T, Gundersen D, El-Salhy M. Diet and effects of diet management on quality of life and symptoms in patients with irritable bowel syndrome. Molecular Medicine Reports. March 2012. doi:https://doi.org/10.3892/mmr.2012.843
22. Mugie SM, Benninga MA, Di Lorenzo C. Epidemiology of constipation in children and adults: A systematic review. Best Practice & Research Clinical Gastroenterology. 2011;25(1):3-18. doi:https://doi.org/10.1016/j.bpg.2010.12.010
23. Smith TK, Park KJ, Hennig GW. Colonic migrating motor complexes, high amplitude propagating contractions, neural reflexes and the importance of neuronal and mucosal serotonin. Journal of Neurogastroenterology and Motility. 2014;20(4):423-446. doi:https://doi.org/10.5056/jnm14092

24. Bull FC, Al-Ansari SS, Biddle S, et al. World health organization 2020 guidelines on physical activity and sedentary behaviour. British Journal of Sports Medicine. 2020;54(24):1451-1462. doi:https://doi.org/10.1136/bjsports-2020-102955
25. Rowell LB, Blackmon JR, Bruce RA. Indocyanine Green Clearance and Estimated Hepatic Blood Flow during Mild to Maximal Exercise in Upright Man *. Journal of Clinical Investigation. 1964;43(8):1677-1690. doi:https://doi.org/10.1172/jci105043
26. Driessen LM, Jong JCK, Wijtzes A, et al. Preschool Physical Activity and Functional Constipation. Journal of Pediatric Gastroenterology and Nutrition. 2013;57(6):768-774. doi:https://doi.org/10.1097/mpg.0b013e3182a313fc
27. Dukas L, Willett WC, Giovannucci EL. Association between physical activity, fiber intake, and other lifestyle variables and constipation in a study of women. The American Journal of Gastroenterology. 2003;98(8):1790-1796. doi:https://doi.org/10.1111/j.1572-0241.2003.07591.x
28. Vargas-García EJ, Vargas-Salado E. [Food intake, nutritional status and physical activity between elderly with and without chronic constipation. A comparative study]. PubMed. 2013;81(3):214-220. https://pubmed.ncbi.nlm.nih.gov/23769250.
29. Zhou C, Zhao E, Li Y, Jia Y, Li F. Exercise therapy of patients with irritable bowel syndrome: A systematic review of randomized controlled trials. Neurogastroenterology and motility : the official journal of the European Gastrointestinal Motility Society. 2019;31(2):e13461. doi:https://doi.org/10.1111/nmo.13461
30. Tantawy SA, Kamel DM, Abdelbasset WK, Elgohary HM. Effects of a proposed physical activity and diet control to manage constipation in middle-aged obese women. Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy. 2017;10(10):513-519. doi:https://doi.org/10.2147/DMSO.S140250
31. Schnelle JF, Leung FW, Rao SSC, et al. A Controlled Trial of an Intervention to Improve Urinary and Fecal Incontinence and Constipation. Journal of the American Geriatrics Society. 2010;58(8):1504-1511. doi:https://doi.org/10.1111/j.1532-5415.2010.02978.x
32. De Schryver AM, Keulemans YC, Peters HP, et al. Effects of regular physical activity on defecation pattern in middle-aged patients complaining of chronic constipation. Scandinavian Journal of Gastroenterology. 2005;40(4):422-429. doi:https://doi.org/10.1080/00365520510011641
33. Shiro Y, Arai YC, Ikemoto T, Hayashi K. Stool consistency is significantly associated with pain perception. Green J, ed. PLOS ONE. 2017;12(8):e0182859. doi:https://doi.org/10.1371/journal.pone.0182859
34. Gaskell SK, Rauch CE, Parr A, Costa RJS. Diurnal versus Nocturnal Exercise—Impact on the Gastrointestinal Tract. Medicine & Science in Sports & Exercise. 2020;Publish Ahead of Print. doi:https://doi.org/10.1249/mss.0000000000002546
35. Brouns F, Beckers E. Is the Gut an Athletic Organ? Sports Medicine. 1993;15(4):242-257. doi:https://doi.org/10.2165/00007256-199315040-00003
36. Black CJ, Ford AC. Chronic idiopathic constipation in adults: epidemiology, pathophysiology, diagnosis and clinical management. Medical Journal of Australia. 2018;209(2):86-91. doi:https://doi.org/10.5694/mja18.00241

37. Simoes GD, De Araujo Martins F, Capistrano VLM Jr, Loureiro LL, De Souza MLR. Sleep quality in CrossFit: a Cross-Sectional study. Sleep Science. 2024;17(01):e16-e25. doi:https://doi.org/10.1055/s-0043-1778014
38. Bycura D, Santos AC, Shiffer A, et al. Impact of different exercise modalities on the human gut microbiome. Sports. 2021;9(2):14. doi:https://doi.org/10.3390/sports9020014
39. Triantafyllou K, Chang C, Pimentel M. Methanogens, methane and gastrointestinal motility. Journal of Neurogastroenterology and Motility. 2014;20(1):31-40. doi:https://doi.org/10.5056/jnm.2014.20.1.31
40. Parthasarathy G, Chen J, Chen X, et al. Relationship Between Microbiota of the Colonic Mucosa vs Feces and Symptoms, Colonic Transit, and Methane Production in Female Patients With Chronic Constipation. Gastroenterology. 2016;150(2):367-379.e1. doi:https://doi.org/10.1053/j.gastro.2015.10.005
41. Son J, Jang LG, Kim BY, Lee S, Park H. The effect of athletes' probiotic intake may depend on protein and dietary fiber intake. Nutrients. 2020;12(10):2947. doi:https://doi.org/10.3390/nu12102947
42. Wald A, Van Thiel DH, Hoechstetter L, et al. Gastrointestinal transit: The effect of the menstrual cycle. Gastroenterology. 1981;80(6):1497-1500. doi:https://doi.org/10.1016/0016-5085(81)90263-8
43. Campbell KG, Batt ME, Drummond A. Prevalence of pelvic floor dysfunction in recreational athletes: a cross-sectional survey. International Urogynecology Journal. 2023;34(10):2429-2437. doi:https://doi.org/10.1007/s00192-023-05548-8
44. I Xinias, A Mavroudi. Constipation in Childhood. An update on evaluation and management. PubMed. 2015;19(1):11-19. https://pubmed.ncbi.nlm.nih.gov/26435640.
45. Leung AK, Hon KL. Paediatrics: how to manage functional constipation. Drugs in Context. 2021;10:1-14. doi:https://doi.org/10.7573/dic.2020-11-2
46. Tabbers MM, DiLorenzo C, Berger MY, et al. Evaluation and treatment of functional constipation in infants and children. Journal of Pediatric Gastroenterology and Nutrition. 2014;58(2):258-274. doi:https://doi.org/10.1097/mpg.0000000000000266