Hrana u zdravlju i bolesti, znanstveno-stručni časopis za nutricionizam i dijetetiku (2024) 13 (2) 53-61
Food in Health and Disease, scientific-professional journal of nutrition and dietetics (2024) 13 (2) 53-61

NUTRITION STATUS AND BOWEL HABITS IN COLORECTAL CANCER PATIENTS BEFORE AND AFTER NUTRITION COUNSELING

Nevena Ćorić[1,2*], Ines Banjari[2,3], Inga Marijanović[1,4], Ljubica Vazdar[5,6], Ilijan Tomaš[7,8]

[1]University Clinical Hospital Mostar, Ulica Kralja Tvrtka bb, 88000 Mostar, Bosnia and Herzegovina
[2]University of Mostar, Faculty of Agriculture and Food Technology, Biskupa Čule bb 88000 Mostar, Bosnia and Herzegovina
[3]Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, 31000 Osijek, Croatia
[4]University of Mostar, School of Medicine, Bijeli Brijeg bb, 88000 Mostar, Bosnia and Herzegovina
[5]University Hospital Center "Sestre Milosrdnice", Vinogradska cesta 29, 10000 Zagreb, Croatia
[6]University of Zagreb, School of Medicine, Šalata 3, 10000 Zagreb, Croatia
[7]University Hospital Center Osijek, Josipa Huttlera 4, 31000, Osijek, Croatia
[8]Josip Juraj Strossmayer University of Osijek, Faculty of Medicine, Josipa Huttlera 4, 31000 Osijek, Croatia

original scientific paper

Summary

The aim of this study was to examine the nutritional status and bowel habit before and after nutrition counseling in CRC patients. The study included 43 CRC patients (22 females and 21 males) with a mean age of 61.23±9.22. All participants received nutritional counseling, which included dietary guidelines for managing defecation during treatment (constipation or diarrhea). Nutritional status included anthropometric measurements: height and weight, body mass index, waist, hip, waist to hip ratio, and mid-upper arm circumference. For the bowel habit, a questionnaire examines bowel habits including bowel movement frequency, consistency, quantity, feeling of discomfort during bowel movement, and laxative use. Anthropometric measurements and questionnaires were performed at the initial nutritional counseling - prior to the start of treatment, and after a minimum of 6 months. Results show that 65.1% of CRC patients experienced weight loss in the three months prior to the initial nutrition counseling (base line). At endpoint, more patients were categorized as overweight (39.5%) or obese (23.3%) than at baseline. A statistically significant difference was observed between the baseline and endpoint measurements for all anthropometric variables, including weight, BMI, waist and hip circumference, and MUAC. Means of weight, BMI, waist and hip circumference, and MUAC were higher at the endpoint and after the nutrition education. There was a statistically significant difference in stool frequency in CRC patients at baseline and at the endpoint of the study. A larger number of patients (60.5%) had stool daily at the end point and after nutrition counseling than at baseline (48.8%). Also, the proportion of cases having at least 2–3 stools per day, at baseline was higher (44.2%) than at endpoint (32.6%). No statistically significant differences were observed in stool consistency, quantity, or discomfort during the follow-up. This study found pre-treatment weight loss in CRC patients, followed by significant weight regain and improvements in bowel function, potentially due to individualized nutritional education, though further research is needed to confirm these effects.

Keywords: colorectal cancer, nutritional status, bowel habits, defecation

Abbreviations:
BMI - Body mass index
ICD - International classification of disease
CRC - Colorectal cancer
RCRC - Right sided colorectal cancer
LCRC - Left sided colorectal cancer
MUAC - Mid upper arm circumference
WHR - Waist to hip ratio

Introduction

Colorectal cancer (CRC) represents a significant global health burden, impacting millions of lives each year. In 2022, GLOBOCAN reported that colorectal cancer was the third most common cancer globally, with 1 926 425 (9.6%) new cases, and the second leading cause of cancer-related deaths, totaling 904 019 (9.3%) (Globocan, 2022). According to the latest available data from the International Agency for Research on Cancer, in Bosnia and Herzegovina CRC is the second most common cancer, after lung cancer, with an incidence of 26.3 per 100,000 inhabitants (Ferlay et al., 2024).

This is a multifactorial disease (Negrichi and Taleb, 2020) which includes non-modifiable and modifiable risk factors. Non-modifiable risk factors include age (40 to 50 years), gender (the incidence is higher in males), genetics, personal history of cancer and polyps, inflammatory bowel disease and race ethnicity. Modifiable risk factors include diet, physical inactivity, obesity, smoking, alcohol use, diabetes and insulin resistance (American Cancer

*Corresponding author: nevena.coric@aptf.sum.ba

Society, 2024). This is the only cancer with an extremely high correlation with diet quality, and it is also believed that dietary and lifestyle habits (such as physical activity) have a greater influence than genetic predisposition (Banjari, 2018).

While extensive research has demonstrated the preventive role of specific dietary and lifestyle factors on CRC, the impact of nutritional status and dietary interventions on CRC treatment outcomes remains relatively unexplored (Martinis et al., 2023).

The nutritional status of patients with CRC significantly influences clinical outcomes, with malnourished and obese individuals exhibiting higher mortality rates compared to those with normal nutritional status (Negrichi and Taleb, 2020). Cancer stage, comorbidities, dietary and lifestyle factors, type of treatment, and treatment-related side effects, including appetite loss, nausea, vomiting, diarrhea, and constipation, collectively contribute to the patient's nutritional status. The body's response to cancer often involves inflammation, which can lead to muscle wasting or cachexia, specific for cancer patients (Zietarska et al., 2017). While many CRC patients maintain or even gain weight (Zietarska et al., 2017), the aforementioned metabolic and nutritional changes can adversely impact quality of life, life expectancy and the development of complications.

Malnutrition, a state of suboptimal nutritional status, arises from an imbalance between nutrient intake (macronutrients or micronutrients) and physiological demands, leading to compromised health. This imbalance can manifest as undernutrition, overnutrition, or micronutrient deficiencies. Under- and overnutrition can coexist, creating a dual burden of malnutrition (Himmelgreen and Miller, 2018). Nutritional status encompasses a range of indicators reflecting nutritional, physical, and health conditions, assessed through various methods. These include anthropometric measurements of body size and composition, biochemical analysis, dietary intake assessment, physical examination, and physical activity measurement (Himmelgreen and Miller, 2018).

Previous studies on CRC patients have demonstrated that many of them suffer from severe long-term bowel dysfunction and that the symptom pattern differs between patients undergoing right and left-sided colon resection (Bräuner et al., 2023). Due to the tumor's location in the large intestine and the type of treatment, which may involve surgical resection alongside radiotherapy or chemotherapy, patients may encounter a range of bowel complications. Typical symptoms of bowel dysfunction are diarrhea, urge for defecation, fecal incontinence, bloating, constipation and difficulties with evacuation (Borre et al., 2022; Lai et al., 2013). They result with discomfort, embarrassment, and social isolation, worsening a patient's quality of life. Additional deterioration of the quality of life is present in patients with stoma.

Consequently, nutrition of CRC patients should be adjusted to their condition and individual needs (Lewandowska et al., 2022). However, the dietary information provided often lacks clarity, consistency, and supporting evidence. Some information can lead to confusion among patients, like in case of increased fiber intake (Borre et al., 2022). Previous findings indicate that CRC patients would benefit from dietary guidance during the immediate post-treatment period to alleviate symptoms and address concerns about food choices (Anderson et al., 2013).

The aim of this study was to examine the nutritional status and bowel habits before and after nutrition counseling in CRC patients.

Participants and methods

The research was conducted between August 2021 and June 2024 at the University Clinical Hospital Mostar, Bosnia and Herzegovina. This study was approved by the Ethics Committee of the University Clinical Hospital Mostar, Bosnia and Herzegovina (Decision No. 1013/21, September 20, 2021). All patients diagnosed with C18-C21 (according to the international classification of diseases) were recruited at the Oncology Clinic during their initial consultation with an oncologist. Patients were enrolled in the study either prior to the initiation of oncology therapy or during their first therapy session, following any surgical procedures. All patients signed informed consent to participate in the study.

First part of the study-specific questionnaire was collected via direct interview at baseline. It included general questions (age, gender), data on sociodemographic characteristics (e.g. place of residence, number of household members, working status, education, average monthly income), and single focused question about weight loss in the last three months, questions regarding general dietary and lifestyle habits e.g. number of meals per day, skipping meals, individual food preference, avoidance, and tolerance for spicy foods, smoking and alcohol consumption. The dietary assessment of patients, including energy, macronutrient, and micronutrient intake, was conducted using a 24-hour dietary recall and a food frequency questionnaire (FFQ). However, the results of this analysis are not presented within the scope of this study.

Data regarding the diagnosis of CRC (e.g. date of diagnosis, type of treatment) were collected from personal health charts.

Anthropometric measurements and bowel habit questionnaire were collected at baseline and after a minimum of 6 months follow-up (endpoint). Nutrition education was performed at baseline and after 3 months (midpoint) post diagnosis.

Nutritional status included anthropometric measurements: body height and weight, waist, hip, waist to hip ratio (WHR) and mid-upper arm circumference (MUAC). Digital column scale Seca 769 (Hamburg, Germany) was used to measure body height (in meters) and weight (in kilograms; ± 0.5 kg), with patients being barefoot and dressed in lightweight clothing and head positioned in the Frankfort Horizontal.

Body mass index (BMI) was calculated as a person's weight in kilograms (kg) divided by the height in meters squared (kg/m^2). The plastic non-elastic measuring tape was used to measure waist, hip and MUAC. Waist circumference was measured with the subject standing, positioning the measuring tape horizontally just above the navel. The values were recorded in centimeters, rounded to whole numbers. Hip circumference was measured by placing the tape around the widest part of the hips. WHR was calculated dividing the circumference of waist by the circumference of the hip. For MUAC, the measurement was taken on a relaxed, non-dominant arm extended along the body, with the tape positioned horizontally 1 cm above the midpoint of the upper arm. This measurement was recorded in centimeters, rounded to one decimal place.

Patients were divided into four categories depending on their calculated BMI: underweight (less than 18.5 kg/m^2), normal (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese (≥ 30 kg/m^2), based on WHO 2008 classification.

For the bowel habit, a questionnaire from the European Prospective Investigation Into Cancer and Nutrition (EPIC) study was used (Park et al., 2009), translated into Croatian language. It examines bowel habits including bowel movement frequency, consistency, quantity, feeling of discomfort during bowel movement, and laxative use. Participants categorized bowel movement frequency into seven groups (more than six times daily, four or five times daily, two or three times daily, daily, every three or four times a week, two or three times a week and less than once a week), consistency into three levels (hard, soft, loose), and quantity into three categories (small, medium, large). Discomfort during bowel movements (no, yes) and laxative use were also recorded, with frequency (<1/d, daily, and >1/d) and brands of laxatives specified if applicable.

Nutritional counseling was conducted at the Department of Nutrition of the University Clinical Hospital Mostar by a nutritionist/ dietician.

The nutritional education was specifically designed to be in line with all current recommendations for CRC survivors (Fretwell et al., 2024; Rock et al. 2022; WCRF/ AICR, 2018.; Van Blarigan and Meyerhardt, 2015). The nutritional education for the CRC patients emphasized maintaining body weight. Recommendations included avoiding alcohol and processed meats and other processed food with monosodium glutamate, moderating red meat consumption (2 times per week), increasing intake of vegetables, fruits, whole grains, and legumes, in a form in which the patient will tolerate it (boiled and/or mashed) and consuming at least two servings of dairy daily or other calcium-rich foods, and at least two servings of fish per week. Easily digestible food was recommended without hot and strong spices. Also, it was recommended to increase food rich in omega-3 fatty acids, such as fish, flax, chia and other seeds and nuts, olive, flaxseed and other cold pressed plant oils.

Nutritional education was further individualized based on each patient's specific conditions, with particular attention to their nutritional status and defecation patterns.

For example, during radiotherapy greater attention was paid on consuming cooked vegetables, pureed when necessary, and maintaining a moderate fiber intake.

The education was conducted in a one-on-one counseling session with provision of written materials patients were bringing home for their personal use. All patients also received a weekly meal plan.

Statistical analysis

The results were analyzed using IBM SPSS for Windows, version 25 [*IBM Corp., Armonk, NY, USA*]. For categorical variables, results are expressed as percentages, mean and standard deviation. To assess the normality of the investigated variables and select the appropriate statistical test, the Shapiro-Wilk test was used. For variables such as weight, BMI, waist and hip circumference, and MUAC, the distribution was found to be normal, enabling the use of paired samples t-tests. Categorical data with repeated measures were analyzed using Chi square test.

For all analyses, p-value <0.05 was considered statistically significant.

Results and Discussion

A total of 43 individuals with CRC of all clinical stages were included, with 21 (48.8%) men and 22

(51.2%) women. The average age of all patients was 61.23 years (SD=9.22). Sociodemographic characteristics are shown in Table 1. Average monthly income of participants, was 355,41 EUR (SD=210,74).

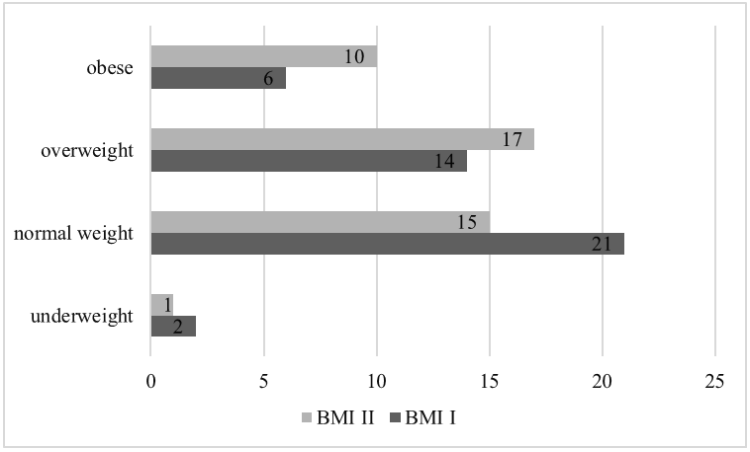
Out of the total number of respondents, 9.3% have RCRC (1 female, 3 males), 58.1% have LCRC (13 females and 13 males) 32.6% patients (8 females and 5 males) have an unspecified type of CRC (ICD: C18.9). The RCRC include cecum, appendix, ascending colon, hepatic flexure and proximal two thirds of the transverse colon. The LCRC includes the left side of the colon, more precisely transverse colon, splenic flexure, descending colon, sigmoid colon and rectum (Baran et al., 2018) and its incidence has been higher than the RCRC (Lee et al., 2015).

Table 1. Sociodemographic characteristics of CRC patients (N=43)

	n (%)
Marital status	
Married	36 (83.7%)
Single	7 (16.3%)
Work status	
Employed	7 (16.3%)
Unemployed	14 (32.6%)
Retired	22 (51.2%)
Education level	
Primary school	4 (9.3%)
Secondary school	26 (60.5%)
Non-university degree	5 (11.6%)
University degree	8 (18.6%)
Number of household members	9 (20.9%)
1	13 (30.2%)
2	14 (32.6%)
3	7 (16.3%)
>4	
Residential status	
Homeowner	42 (97.7%)
Living with family	1 (2.3%)

Change in nutritional status

Weight loss 3 months prior to the initial nutrition counseling (baseline) was reported by 28 (65.1%) patients, while 7 (16.3%) patients reported gaining weight during the same period. In the following 6 months, a substantial number of patients gained weight (Figure 1).



*BMI I - baseline; BMI II - endpoint

Figure 1. Change of BMI in CRC patients

At the endpoint, according to the calculated BMI, significantly more patients (p=0.000) were categorized as overweight (39.5%) or obese (23.3%) than at baseline (32.6% and 14.0%) (Figure 1). During the six-month follow-up period, 10 (23.3%) patients experienced weight loss, 19 (44.2%) patients gained up to 5 kg of weight, and 14 (32.6%) gained more than 5 kg of weight. Changes in all anthropometric variables between the two time points were statistically significantly different (Table 2). Between gender, statistically significant difference was observed between weight (p=0.002) and waist circumference (p=0.000), as also between WHR (p=0.000). On average, women exhibited a greater increase in body mass (84.36±12.57 at baseline to 86.59±12.57 compared to males 96.76±11.72 to 100.75±11.73), while men experienced a more pronounced increase in waist circumference (84.605±16.41 to 87.98±15.38 compared to women 67.25±12.47 to 71.64±13.38).

Table 2. Anthropometric measurement at baseline and endpoint in CRC patients (N=43)

	Mean ± SD	***p***	***t***
Weight (kg)			
Weight I	75.7 ± 16.8	**0.000**	-3.996
Weight II	79.6 ± 16.4		
BMI (kg/m^2)			
BMI I	25.4 ± 5.3	**0.001**	-3.625
BMI II	26.7 ± 5.0		
Waist circumference (cm)			
Waist I	89.8 ± 13.6	**0.002**	-3.305
Waist II	92.6 ± 13.9		
Hip circumference (cm)			
Hip I	103.7 ± 9.9	**0.003**	-3.230
Hip II	106.4 ± 10.1		
WHR			
WHR I	0.85 ± 0.07	**0.000**	-0.894
WHR II	0.86 ± 0.08		
MUAC (cm)			
MUAC I	29.4 ± 4.3	**0.035**	-2.185
MUAC II	30.2 ± 3.4		

*"I" refers to baseline values and "II" refers to endpoint values after the nutrition education

We hypothesized that weight gain may be attributed to increased food intake to compensate for nutritional loss and a decrease in physical activity following surgery. Yet, BMI at the time of diagnosis has been identified as an independent prognostic factor in patients with early-stage CRC who underwent primary tumor resection and received adjuvant chemotherapy with curative intent (Renfro et al., 2016). Study by Lee et al. (2020) showed that obesity has a negative prognostic role in CRC patients undergoing adjuvant chemotherapy. Also, according to Meyerhardt et al. (2017) the impact of obesity on cancer outcomes is inconsistent according to sex, where obesity (BMI > 30 kg/m^2) was associated with poor survival in women but not in men. In analysis by Sinicrope et al. (2013) based on 25,291 patients from the ACCENT (Adjuvant Colon Cancer End Points) database, during a median follow-up of 7.8 years, obese and underweight patients with stage II or III disease had significantly poorer survival compared with overweight and normal-weight patients. For metastatic CRC, BMI was a prognostic factor for the overall survival and progression-free survival, with an L-shaped pattern. Risk of progression and/or death was greatest for low BMI, risk decreased as BMI increased to approximately 28 kg/m^2, and then it plateaued (Renfro et al., 2016).

The evaluation of waist circumference to assess the risks associated with obesity or overweight is supported by research (WHO, 2011). A 2-cm increase in waist circumference, a measure of central obesity, was associated with a 4% greater risk of CRC (Moghaddam et al., 2007). Waist circumference and waist to hip ratio could also be a predictor of mortality and morbidity after colorectal surgery, and according to Kartheuser et al. (2013) even better than BMI or body surface area. Abdominal obesity is linked to insulin resistance, abnormal blood lipid levels, and widespread inflammation, all of which are associated with an increased risk of CRC. Visceral adiposity, along with its aggravation, is associated with colorectal adenoma, which can progress to CRC (Gonzalez-Gutierrez et al., 2024). BMI, waist circumference, and increased waist-to-hip ratio are associated with significant increases in CRC in men and this association appears to be less strong in women, probably because of the protective effect of estrogens (Gonzalez-Gutierrez et al., 2024), and higher percentage of visceral fat in men (Chaplin et al., 2022). Our results are in line with literature evidence. This could also explain results from this research, where men experienced a more pronounced increase in waist circumference.

Change in bowel habits

At baseline, eight patients already had a colostomy, and two more patients till the endpoint. Among patients with stomas, only one had RCRC, the remaining patients had LCRC. Bowel habits of CRC patients at baseline and at the endpoint are presented in Table 3.

Table 3. Bowel habits in CRC patients at baseline and at endpoint, after nutrition counseling (N=43)

Bowel movement	**I**	**II**	***p***
Frequency			
≤ 3-4 stool/week	3 (7,0%)	3 (7.0%)	
7 stools/week (daily)	21 (48,8%)	26 (60.5%)	**0.049**
≥ 2-3 stool/day	19 (44.2%)	14 (32.6%)	
Consistency			
Hard	11 (25.6%)	6 (14.0%)	
Soft	27 (62.8%)	35 (81.4%)	0.682
Loose	5 (11.6%)	2 (4.7%)	
Quantity			
Small	14 (32.6%)	6 (14.0%)	
Medium	25 (58.1%)	36 (83.7%)	0.662
Large	4 (9.3%)	1 (2.3%)	
Feeling			
No discomfort	31 (72.1%)	36 (83.7%)	0.966
Discomfort	12 (27.9%)	7 (16.3%)	
Laxative use			
No	38 (88.4)	42 (97.7%)	**0.005**
Yes	5 (11.6%)	1 (2.3%)	

*"I" refers to baseline values and "II" refers to endpoint values after the nutrition education

There was a statistically significant difference (p=0.049) in stool frequency in CRC patients during the follow-up. More patients (60.5%) reported regular bowel movement (daily) at the endpoint as compared to the baseline (48.8%). The number of patients having at least 2–3 stools per day diminished from 44.2% at baseline to 32.6% at endpoint. This reduction was particularly observed in LCRC patients, though it was not statistically significant. Laxative use was significantly reduced during the study; from 11.6% at baseline to 2.3% at endpoint (p=0.005). Laxatives used by those patients were non-fiber laxatives (one commercial, herbal preparations and fruits).

Stool consistency, quantity, or discomfort during defecation did not change significantly during the follow-up. However, almost 20% of patients reported a shift in stool consistency during the study. Specifically, a smaller number of patients experienced harder stools and fewer reported discomfort during bowel movements at endpoint (Table 3). Larger number of patients with LCRC had hard stool at both study points, which is consistent with the study of Brauner et al. (2023).

A significant number of patients reported heightened sensitivity to some foods (18 patients; 41.9%) particularly legumes (beans and lentils), as well as peppers, onions, and milk, which exacerbated their gastrointestinal symptoms. Preference towards hot and spicy food was reported by 17 (39.5%) patients. The most common foods they avoided even before their first nutritional education were sweets and soft and fizzy drinks (17 patients; 37.2%)).

Given that all CRC patients treated at the University Clinical Hospital Mostar, were included in the study, the method of treatment and its influence on defecation were not taken into account. The basic treatment of CRC is classical or laparoscopic resection of the tumor with the removal of the surrounding lymph nodes (Lewandowska et al., 2022). Chemotherapy or chemoradiation is advised for patients with unresectable tumors or who are medically unfit for surgery. Adjuvant chemotherapy is recommended for post-surgical patients with stage III or high-risk stage II disease. Pre-operative neoadjuvant therapy may be administered to patients with resectable high-stage colonic disease (T4 tumors) in order to downstage the tumor (Szymańska, 2018), so this explains why some patients had a stoma implanted at endpoint.

Bowel dysfunction, characterized by changes in bowel frequency, incontinence, abnormal sensations, and evacuation difficulties, is particularly prevalent among patients with rectal cancer. These problems are mostly pronounced within the initial year post-diagnosis, especially during the first six months (Lai et al., 2013).

Findings from the prospective study by Citronberg et al. (2014) suggest that the risk of CRC increases with non-fiber laxative use and decreases with fiber laxative use. Overall, despite the common use of laxatives among patients undergoing treatment, current research on this subject is still limited. Also, studies on the association between spicy food intake and cancer risk have reported inconsistent results. Various *in vitro* studies have demonstrated anticancer activity of chemicals present in spices. A review by Mani et al. (2020) showed significant negative correlation between spice intake and CRC risk, indicating their potentially preventive effect, possibly even risk-lowering agents in populations at higher risk of CRC. A study by Mahfouz et al. (2014) showed that higher consumption of spicy foods, as well as red meat, preserved foods, artificial sweeteners, fast foods, soft drinks, and processed meat, were significantly related to onset of CRC. Baseline assessments of general dietary habits, including preferences, food avoidance, and tolerance, revealed that a significant proportion of CRC patients had already modified their diets to manage bowel function, avoiding certain foods even before receiving nutritional education. This aligns with findings from the study by Borre et al. (2022) which showed that food categories such as fatty foods, spices, sweets, meat, and alcohol were most frequently reported as having a negative impact on bowel function, while vegetables, fruits, and dairy were commonly perceived to improve it. The dietary and bowel symptom information provided to patients can significantly influence their perception of diet and bowel-related symptoms (Borre et al., 2022).

Conclusion

Results from this study showed pre-treatment weight loss among CRC patients, likely attributable to surgical resection of the tumor, preoperative preparation, or diagnostic procedures. At the endpoint, a significant proportion of patients regained their initial weight, with notable increases in body weight and other anthropometric measures such as BMI, waist and hip circumference, and MUAC.

In regard to bowel dysfunction, a greater proportion of patients exhibited a normalization of bowel habits, characterized by daily stool passage and an improvement in stool consistency. The observed improvements may be attributed to the effectiveness of individualized nutritional education. However, further research is required to validate this hypothesis, as this study does not address the impact of treatment techniques on defecation patterns or stool characteristics.

References

American Cancer Society, 2024. https://www.cancer.org/cancer/types/colon-rectal-cancer/causes-risks-prevention/risk-factors.html

Anderson, AS., Steele, R., Coyle, J. (2013): Lifestyle issues for colorectal cancer survivors—perceived needs, beliefs and opportunities, *Supportive Care in Cancer* 21, 35-42.

Banjari, I. (2018): Colorectal carcinoma and nutrition-what does the evidence say?, *Food in Health and Disease* 7 Special Issue, 58-63.

Baran, B., Ozupek, NM., Tetik, NY., Acar, E., Bekcioglu, O., Baskin, Y. (2018): Difference between left-sided and right-sided colorectal cancer: a focused review of literature, *Gastroenterology research* 11(4), 264. https://doi.org/10.14740/gr1062w

Barazzoni, R., Gortan Cappellari, G. (2020): Double burden of malnutrition in persons with obesity, *Reviews in Endocrine and Metabolic Disorders* 21(3), 307-313. https://link.springer.com/article/10.1007/s11154-020-09578-1

Borre, M., Fassov, J., Juul, T., Laurberg, S., Christensen, P., Bräuner, A. B., ... Krogh, K. (2022): Diet and bowel symptoms among colon cancer survivors, *Acta Oncologica* 61(10), 1192-1199. https://doi.org/10.1080/0284186X.2022.2101901

Bräuner, A. B., Avellaneda, N., Christensen, P., Drewes, A. M., Emmertsen, K. J., Krogh, K., ... Juul, T. (2023): Prospective evaluation of bowel function and quality of life after colon cancer surgery–is it time for routine screening for late sequelae?, *Acta Oncologica* 62(9), 1132-1142. https://doi.org/10.1080/0284186X.2023.2246102

Citronberg, J., Kantor, E. D., Potter, J. D., White, E. (2014): A prospective study of the effect of bowel movement frequency, constipation, and laxative use on colorectal cancer risk, *Official journal of the American College of Gastroenterology| ACG* 109(10), 1640-1649. https://doi.org/10.1038/ajg.2014.233

Chaplin, A., Rodriguez, R. M., Segura-Sampedro, J. J., Ochogavía-Seguí, A., Romaguera, D., Barceló-Coblijn, G. (2022): Insights behind the relationship between colorectal cancer and obesity: is visceral adipose tissue the missing link?, *International journal of molecular sciences* 23(21), 13128. https://doi.org/10.3390/ijms232113128

Ferlay J., Ervik M., Lam F., Laversanne M., Colombet M., Mery L., Piñeros M., Znaor A., Soerjomataram I., Bray F. (2024): Global Cancer Observatory: Cancer Today. Lyon, France: International Agency for Research on Cancer. Available from: https://gco.iarc.who.int/today, accessed 18 February 2024.

Fretwell, A., Dobson, C., Orange, S. T., Corfe, B. M. (2024): Diet and physical activity advice for colorectal cancer survivors: critical synthesis of public-facing guidance, *Supportive Care in Cancer* 32(9), 609. https://doi.org/10.1007/s00520-024-08797-5

Globocan, 2022. (Version 1.1) https://gco.iarc.who.int/today/en/dataviz/pie?mode=cancer&types=1&sexes=0&populations=900

Gonzalez-Gutierrez, L., Motiño, O., Barriuso, D., de la Puente-Aldea, J., Alvarez-Frutos, L., Kroemer, G., ... Senovilla, L. (2024): Obesity-Associated Colorectal Cancer, *International Journal of Molecular Sciences* 25(16), 8836. https://doi.org/10.3390/ijms25168836

Himmelgreen, D. A., M. Miller, E. (2018): Nutritional status, *The International Encyclopedia of Biological Anthropology* 1-4. https://doi.org/10.1002/9781118584538.ieba0542

Lai, X., Wong, F. K. Y., Ching, S. S. Y. (2013): Review of bowel dysfunction of rectal cancer patients during the first five years after sphincter-preserving surgery: a population in need of nursing attention, *European Journal of Oncology Nursing* 17(5), 681-692.

Lee GH., Malietzis G., Askari A., Bernardo D., Al-Hassi HO., Clark, SK. (2015): Is right-sided colon cancer different to left-sided colorectal cancer?–a systematic review, *European Journal of Surgical Oncology (EJSO)* 41(3), 300-308. https://doi.org/10.1016/j.ejso.2014.11.001

Lee, D. W., Cho, S., Shin, A., Han, S. W., Kim, T. Y. (2020): Body mass index and body weight change during adjuvant chemotherapy in colon cancer patients: results from the AVANT trial, *Scientific Reports* 10(1), 19467. https://doi.org/10.1038/s41598-020-76643-9

Lewandowska A., Religioni U., Czerw A., Deptała A., Karakiewicz B., Partyka O. et al. (2022): Nutritional treatment of patients with colorectal cancer, *International Journal of Environmental Research and Public Health* 19(11), 6881. https://doi.org/10.3390/ijerph19116881

Mahfouz, E. M., Sadek, R. R., Abdel-Latief, W. M., Mosallem, F. A. H., Hassan, E. E. (2014): The role of dietary and lifestyle factors in the development of colorectal cancer: case control study in Minia, Egypt, *Central European Journal of Public Health* 22(4), 215.

Mani, S., Pramanik, N., Rao, D., Sharma, S., Akhmetov, T. (2020): The Negative Correlation of Spice Intake and Colorectal Cancer: A Statistical Analysis of Global Health Databases, *International Journal of Medical Students* 8(3), 238-244.

Martinis, I., Pugelnik, J., Šporčić, M. (2023): Važnost procjene nutritivnog statusa bolesnika s kolorektalnim karcinomom, *Hrana u zdravlju i bolesti* 12(1), 33-41.

Meyerhardt, J. A., Kroenke, C. H., Prado, C. M., Kwan, M. L., Castillo, A., Weltzien, E., ... Caan, B. J. (2017): Association of weight change after colorectal cancer diagnosis and outcomes in the Kaiser Permanente Northern California population, *Cancer Epidemiology, Biomarkers & Prevention* 26(1), 30-37. https://doi.org/10.1158/1055-9965.EPI-16-0145

Moghaddam, A.A., Woodward, M., Huxley, R. (2007): Obesity and risk of colorectal cancer: a meta-analysis of 31 studies with 70,000 events, *Cancer Epidemiology Biomarkers & Prevention* 16(12), 2533-2547. https://doi.org/10.1158/1055-9965.EPI-07-0708

Negrichi, S., Taleb, S. (2020): Evaluation of nutritional status of colorectal cancer patients from algerian east using anthropometric measurements and laboratory assessment, *Iranian Journal of Public Health* 49(7), 1242. https://doi.org/10.18502/ijph.v49i7.3577

Park, J.Y., Mitrou, P.N., Luben, R., Khaw, K.T., Bingham, S.A. (2009): Is bowel habit linked to colorectal cancer? - Results from the EPIC-Norfolk study, *European Journal of Cancer* 45(1), 139-145.

Renfro, L.A., Loupakis, F., Adams, R.A., Seymour, M.T., Heinemann, V., Schmoll, H.J. et al. (2016): Body mass index is prognostic in metastatic colorectal cancer: pooled analysis of patients from first-line clinical trials in the ARCAD database, *Journal of Clinical Oncology* 34(2), 144. https://doi.org/10.1200/JCO.2015.61.6441

Rock, C.L., Thomson, C.A., Sullivan, K.R., Howe, C.L., Kushi, L.H., Caan, B.J., ... McCullough, M.L. (2022): American Cancer Society nutrition and physical activity guideline for cancer survivors, *CA: a cancer journal for clinicians* 72(3), 230-262. https://doi.org/10.3322/caac.21719

Sinicrope, F.A., Foster, N.R., Yothers, G., Benson, A., Seitz, J.F., Labianca R, ... Adjuvant Colon Cancer Endpoints (ACCENT) Group. (2013): Body mass index at diagnosis and survival among colon cancer patients enrolled in clinical trials of adjuvant chemotherapy, *Cancer* 119(8), 1528-1536. https://doi.org/10.1002/cncr.27938

Szymańska, K. (2018): Cancers of the Colorectum. Diagnosis and Treatment, *Reference Module in Biomedical Sciences* https://doi.org/10.1016/b978-0-12-801238-3.65304-7

Van Blarigan, E.L., Meyerhardt, J.A. (2015): Role of physical activity and diet after colorectal cancer diagnosis, *Journal of Clinical Oncology* 33(16), 1825-1834. https://doi.org/10.1200/JCO.2014.59.7799

World Health Organization (WHO) (2011): Waist circumference and waist-hip ratio: report of a WHO expert consultation, Geneva, 8-11 December 2008. Available from: https://iris.who.int/bitstream/handle/10665/44583/?sequence=1

World Cancer Research Fund/American Institute Cancer Research. (2018): Food, nutrition, physical activity, and the prevention of cancer: a global perspective. Continuous Update Project Expert Report. https://www.wcrf.org/wp-content/uploads/2021/02/Summary-of-Third-Expert-Report-2018.pdf

Ziętarska, M., Krawczyk-Lipiec, J., Kraj, L., Zaucha, R., Małgorzewicz, S. (2017): Nutritional status assessment in colorectal cancer patients qualified to systemic treatment, *Contemporary Oncology/Współczesna Onkologia* 21(2), 157-161. https://doi.org/10.5114/wo.2017.68625