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Impact of seasonal variation in bowel preparation quality on colonoscopy outcomes: a prospective observational study

Nurettin Şahin,[1] Turgut Dönmez,[1] Mahmut Said Değerli,[1] Emine Ayça Şahin,[2] Alpen Yahya Gümüşoğlu,[1] Ferman Tevfik Özyalvaç,[1] Mücahit Berk Elis,[1] Ahmet Surek[1]

[1]Department of General Surgery, University of Health Sciences, Bakırköy Dr. Sadi Konuk Training and Research Hospital, İstanbul, Türkiye
[2]Department of Emergency Medicine, Istanbul Aydın University, VM Medical Park Hospital, İstanbul, Türkiye

ABSTRACT

Introduction: Bowel preparation quality is a key determinant of colonoscopy performance and lesion detection. However, the impact of seasonal variation on bowel preparation remains insufficiently understood. This study aimed to evaluate the effect of bowel preparation quality on colonoscopy outcomes and investigate the roles of seasonal variation and fluid intake.

Materials and Methods: In this prospective observational study, 1,110 patients undergoing elective colonoscopy were included. Bowel preparation quality was assessed using the Boston Bowel Preparation Scale (BBPS). The cecal intubation rate, withdrawal time, polyp detection rate (PDR), and adenoma detection rate (ADR) were analyzed. The effects of seasonal variation and fluid intake were also evaluated.

Results: Adequate bowel preparation was achieved in 90.5% of patients. Inadequate preparation was associated with lower cecal intubation rates, shorter withdrawal times, and reduced lesion detection (PDR: 21.0% vs. 34.7%, p=0.006; ADR: 16.2% vs. 26.9%, p=0.023). Adequate fluid intake significantly improved BBPS scores (p=0.001). Seasonal analysis demonstrated significantly poorer bowel preparation quality during winter (p<0.001).

Conclusions: Bowel preparation quality significantly influences colonoscopy performance and lesion detection. The poorer preparation quality observed during winter suggests that seasonal factors should be considered. Optimizing hydration and accounting for environmental factors may improve colonoscopy quality.

Keywords: Adenoma detection rate, bowel preparation, colonoscopy, hydration, polyp detection rate, seasonal variation

Introduction

Colonoscopy is a cornerstone diagnostic and therapeutic procedure for colorectal diseases and remains the gold standard for colorectal cancer (CRC) screening.[1] In addition, the removal of adenomatous polyps (APs) has been shown to reduce CRC-related mortality.[2] The diagnostic performance and therapeutic effectiveness of colonoscopy are strongly influenced by the quality of bowel preparation. Inadequate bowel cleansing may result in missed mucosal abnormalities, prolonged procedure duration, reduced cecal intubation rates, and the need for repeat examinations.[3,4] This not only negatively affects patient comfort but also imposes an additional burden on the healthcare system.[4]

Bowel cleansing quality may be affected by multiple variables, including patients' demographic and clinical char-

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Correspondence: Nurettin Şahin, Department of General Surgery, University of Health Sciences, Bakırköy Dr. Sadi Konuk Training and Research Hospital, İstanbul, Türkiye
e-mail: dr.nurettinsahin@gmail.com

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acteristics, compliance with preparation instructions, dietary restrictions, and fluid consumption during the preparation period.[5,6] In particular, adequate fluid intake during bowel preparation is considered a key determinant of preparation quality.[7]

Seasonal variations are known to affect individuals' daily habits, dietary patterns, and fluid intake. Environmental temperature and seasonal changes have been reported to influence total fluid consumption and hydration status, with significantly higher water intake during the summer months.[8,9] Accordingly, investigating the influence of seasonal variation on bowel cleansing quality may contribute to improving colonoscopy performance and developing more effective preparation strategies. Nevertheless, evidence regarding the relationship between seasonal variation and bowel preparation quality remains limited.

This study aimed to investigate the association between seasonal variation and bowel preparation quality in patients undergoing elective colonoscopy and to determine the effect of bowel preparation quality on clinical outcomes.

Materials and Methods

A prospective observational study was conducted in the Endoscopy Unit of the Department of General Surgery at our institution between January and December 2025. Eligible patients scheduled for elective colonoscopy were consecutively enrolled throughout the study period, and all clinical and procedural data were prospectively recorded according to a predefined study protocol. Patients aged 18–90 years who underwent elective colonoscopy and provided consent to participate were enrolled in the study. Exclusion criteria included prior gastrointestinal surgery involving the stomach, small intestine, or colorectum; inflammatory bowel disease; renal dysfunction; pregnancy; breastfeeding; and age outside the 18–90-year range. In addition, patients who underwent emergency colonoscopy because of ileus, toxic megacolon, gastrointestinal obstruction, gastrointestinal hemorrhage, or volvulus, as well as those who underwent colonoscopy during hospitalization, were excluded.

Information recorded for each patient included demographic characteristics, comorbid conditions, previous abdominal operations, medication and anticoagulant use, lifestyle factors, family history of colorectal cancer, adherence to bowel preparation instructions, and adverse events related to the preparation process. In addition, the season in which the procedure was performed, adequacy of fluid intake (defined as consumption of the recommended approximately 4 L of fluid), indication for colonoscopy, use of anesthesia, procedure time, withdrawal time, Boston Bowel Preparation Scale (BBPS) scores, number of polyps removed, and histopathological findings of the polyps were recorded.

The polyp detection rate (PDR) and adenoma detection rate (ADR) were evaluated as colonoscopy quality indicators. PDR was defined as the proportion of colonoscopies in which at least one polyp was detected among all colonoscopies performed, whereas ADR was calculated as the percentage of colonoscopic examinations in which at least one adenoma was histopathologically confirmed. Even when multiple polyps or adenomas were detected in the same patient, each patient was counted only once in the calculation of PDR and ADR. Hyperplastic, inflammatory, and hamartomatous polyps were excluded from ADR calculations, whereas tubular, tubulovillous, villous, and serrated adenomas were considered adenomatous lesions.

According to the timing of colonoscopy, patients were divided into four seasonal groups: winter (December–February), spring (March–May), summer (June–August), and autumn (September–November). Clinical and procedural variables were compared among these groups.

Participants were also classified according to hydration status, and BBPS scores and cecal intubation rates were compared between the groups. Furthermore, bowel preparation quality was assessed using a BBPS cutoff value of 6, and patients were subsequently classified as having adequate or inadequate bowel preparation for comparative analyses.

Bowel Preparation Protocol

A uniform bowel cleansing protocol was implemented before the procedure in all participants. Patients were advised to avoid solid foods for 2 days before colonoscopy and to follow a soft or liquid-based diet, including soup and puréed foods. On the day preceding colonoscopy, patients were advised to follow a liquid-only diet consisting of water, strained soup, tea, compote beverages, and pulp-free fruit juices. To achieve effective bowel cleansing, daily fluid consumption of approximately 4 L was encouraged during the preparation period.

Bowel cleansing was initiated on the day before colonoscopy, and no split-dose preparation protocol was used. The first dose of an oral bowel preparation solution containing sennoside A+B calcium (X-M Diet®, 250 mL) was administered at 17:00, diluted in 1 L of water, followed by a recommendation to consume at least 1 additional liter of water. The second dose was administered at 21:00 in the same manner, again followed by intake of at least 1 L of water. On the day of the procedure, bowel cleansing was completed by administering a 210-mL rectal enema (BT Enema®) in the morning.

Colonoscopy Procedure

Colonoscopic examinations were performed in the endoscopy unit by experienced operators using conventional video colonoscopy equipment. During the procedure, patients were placed in the left lateral decubitus position. Sedation was achieved with either intravenous midazolam and fentanyl or general anesthesia, and hemodynamic parameters were continuously monitored throughout the examination.

Cecal intubation was verified by identification of both the appendiceal orifice and the ileocecal valve. Total procedure duration and scope withdrawal time were documented. Withdrawal time was defined as the interval between cecal intubation and withdrawal of the colonoscope to the rectal level.

All detected lesions were recorded. Polypectomy and biopsy were performed when indicated. Therapeutic interventions, including epinephrine injection, argon plasma coagulation, endoscopic mucosal resection (EMR), endoscopic submucosal dissection (ESD), endoclip application, balloon dilation, and stent placement, were performed when necessary.

Assessment of Bowel Preparation

Bowel cleansing quality was evaluated using the Boston Bowel Preparation Scale (BBPS), which assesses bowel cleanliness in three separate colonic regions: the right colon, transverse colon, and left colon. Each segment is assigned a score ranging from 0 to 3, resulting in a total score ranging from 0 to 9.[10]

BBPS segment scores were interpreted as follows:
0: mucosa not assessable because of solid fecal material
1: partial mucosal visualization because of residual stool or opaque fluid
2: adequate visualization despite small amounts of residual material
3: complete visualization of the colonic mucosa without residual stool or fluid

Patients with a total BBPS score of 6 or higher were classified as having adequate bowel cleansing, whereas scores below 6 indicated inadequate preparation. Scoring was performed by the endoscopists who conducted the examinations, without blinding.

Study Endpoints

The primary endpoint of the present study was to assess bowel preparation status using BBPS findings and to compare patients with adequate (BBPS ≥6) and inadequate (BBPS <6) bowel preparation.

Secondary endpoints included assessment of the relationship between bowel cleansing status and colonoscopy performance measures, as well as related clinical outcomes. Parameters analyzed included cecal intubation success, scope withdrawal duration, number of resected polyps, PDR, and ADR. In addition, factors associated with bowel preparation quality, including fluid intake, medication compliance, and seasonal variation, were analyzed.

Statistical Analysis

Continuous variables were summarized using the mean, standard deviation, median, minimum, and maximum values, whereas categorical data were presented as frequencies and percentages. Normality of the data distribution was evaluated using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Comparisons of nonparametric quantitative variables were performed using the Mann–Whitney U and Kruskal–Wallis tests, whereas categorical variables were analyzed using the chi-square test. All statistical analyses were conducted using SPSS version 27.0 software, and p values <0.05 were considered statistically significant.

Ethics Approval

Ethical approval for the study was granted by Bakirköy Dr. Sadi Konuk Training and Research Hospital Non-Interventional Scientific Research Ethics Committee (Approval Number: 2025-02-01, Date: 22.01.2025). Informed consent was obtained from all participants before enrollment, and all study procedures were conducted in accordance with the Declaration of Helsinki.

Results

A total of 1,110 patients were included in the study. The mean age was 56.0±12.3 years, and 53.7% of the patients were female. The mean body mass index (BMI) was 27.8±4.6 kg/m². At least one comorbid condition was present in 51.8% of patients. A history of abdominal surgery was reported in 31.5% of patients, smoking in 21.9%, alcohol use in 2.2%, medication use for chronic disease in 48.3%, anticoagulant use in 22.3%, and a family history of colorectal cancer in 15.7%. Demographic and clinical characteristics are presented in Table 1.

Colonoscopy procedures were performed in winter in 31.3% of cases, autumn in 25.9%, summer in 22.0%, and spring in 20.8%. Adequate fluid intake was achieved in 94.3% of patients, and 97.4% adhered to the prescribed bowel preparation regimen. Adverse events associated with bowel preparation occurred in 42.5% of the study population, with nausea being the most frequently reported symptom (35.9%). The most common indication for colonoscopy was malignancy screening (47.7%), followed by constipation (16.6%).

Colonoscopy findings were normal in 51.1% of patients, whereas polyps were detected in 33.4%. The polyp detection rate (PDR) and adenoma detection rate (ADR) were 33.4% and 25.9%, respectively. The most common histopathological finding was tubular adenoma (20.8%). Cecal intubation was successfully achieved in 94.4% of procedures. The mean examination duration was 15.4±6.7 minutes, whereas the mean withdrawal time was 6.9±3.8 minutes. The mean number of excised polyps was 0.6±1.3. Colonoscopy outcomes are presented in Table 2.

In the segmental Boston Bowel Preparation Scale (BBPS) evaluation, a score of 3 was observed in 39.2% of patients in the right colon, 69.5% in the left colon, and 63.7% in the

Table 1. Demographic and clinical characteristics of the study participants (n=1,110)

Variable	Min–Max	Median	Mean±SD / n (%)
Age, years	19.0–89.0	57.0	56.0±12.3
Sex			
Male			514 (46.3%)
Female			596 (53.7%)
BMI	13.7–47.9	27.3	27.8±4.6
Comorbidity			
No			535 (48.2%)
Yes			575 (51.8%)
Hypertension			340 (30.6%)
Diabetes mellitus			256 (23.1%)
Other			85 (7.7%)
Chronic heart failure			71 (6.4%)
Malignancy			64 (5.8%)
Chronic obstructive pulmonary disease			30 (2.7%)
Asthma			25 (2.3%)
Previous abdominal surgery			350 (31.5%)
Smoking			243 (21.9%)
Alcohol consumption			24 (2.2%)
Regular medication use			536 (48.3%)
Anticoagulant use			247 (22.3%)
Family history of colorectal cancer			174 (15.7%)

BMI: body mass index; SD: standard deviation.

Table 2. Procedural characteristics, indications, colonoscopy findings, and histopathological outcomes (n=1,110)

Variable	Min–Max	Median	Mean±SD / n (%)
Season			
Winter			347 (31.3%)
Spring			231 (20.8%)
Summer			244 (22.0%)
Autumn			288 (25.9%)
Adequate fluid intake			
No			63 (5.7%)
Yes			1,047 (94.3%)
Complete use of bowel preparation medication			
No			29 (2.6%)
Yes			1,081 (97.4%)
Adverse effects of bowel preparation			
None			638 (57.5%)
Nausea			399 (35.9%)
Vomiting			128 (11.5%)
Abdominal pain			10 (0.9%)
Dizziness			23 (2.1%)
Headache			44 (4.0%)
Syncope			4 (0.4%)
Fatigue			4 (0.4%)
Indications for colonoscopy			
Colorectal cancer screening			529 (47.7%)
Constipation			184 (16.6%)
Perianal diseases			115 (10.4%)
Rectal bleeding			89 (8.0%)
Abdominal pain			62 (5.6%)
Polyp surveillance			57 (5.1%)
Anemia			23 (2.1%)
Diverticular disease			20 (1.8%)
Colitis			13 (1.2%)
Diarrhea			9 (0.8%)
Weight loss			9 (0.8%)
Colonoscopy findings			
Normal			567 (51.1%)
Polyp			371 (33.4%)
Diverticulum			100 (9.0%)
Colitis			42 (3.8%)
Perianal disease			28 (2.5%)
Inadequate bowel cleansing			27 (2.4%)

Table 2. Continued

Variable	Min–Max	Median	Mean±SD / n (%)
Malignant tumor			25 (2.3%)
Mucosal lesion			9 (0.8%)
Submucosal lesion			8 (0.7%)
Incomplete procedure			6 (0.5%)
Angiodysplasia			3 (0.3%)
Parasitic infection			2 (0.2%)
Histopathological result			
Tubular adenoma			231 (20.8%)
Normal mucosa			109 (9.8%)
Hyperplastic polyp			64 (5.8%)
Adenomatous polyp			42 (3.8%)
Tubulovillous adenoma			18 (1.6%)
Adenocarcinoma			9 (0.8%)
Serrated adenoma			4 (0.4%)
Inflammatory polyp			4 (0.4%)
Intramucosal carcinoma			2 (0.2%)
Villous adenoma			2 (0.2%)
Hamartomatous polyp			1 (0.1%)
Neuroendocrine tumor			1 (0.1%)
Malignant epithelial tumor			1 (0.1%)
No biopsy			677 (61.0%)
General anesthesia			320 (28.8%)
Cecal intubation			1,048 (94.4%)
Colonoscopy duration, min	4.0–60.0	15.0	15.4±6.7
Withdrawal time, min	0.0–45.0	6.0	6.9±3.8
Number of polyps removed	0.0–11.0	0.0	0.6±1.3

SD: Standard deviation.

transverse colon. The mean total BBPS score was 7.5±1.7. According to the total BBPS score, 105 patients (9.5%) had inadequate bowel preparation (BBPS <6), whereas 1,005 patients (90.5%) had adequate bowel preparation (BBPS ≥6). The distribution of BBPS scores is presented in Table 3.

Comparison of patients with inadequate bowel preparation (BBPS <6) and those with adequate preparation (BBPS ≥6) revealed no significant differences in age, BMI, comorbidity burden, previous abdominal surgery, smoking or alcohol consumption, regular medication use, family history of colorectal cancer, or administration of general anesthesia. In contrast, anticoagulant therapy was more common among patients with inadequate bowel cleansing (p=0.018). Incomplete adherence to the bowel preparation regimen was also significantly associated with poor bowel preparation quality (p=0.036). Cecal intubation success was significantly lower in the inadequate preparation group (p<0.001) (Fig. 1). Moreover, shorter withdrawal times (p=0.001) and a lower number of detected polyps (p=0.002) were observed in these patients (Fig. 2). PDR and ADR were also significantly lower in the inadequate bowel cleansing group. PDR was 21.0% in patients with BBPS <6 and 34.7% in those with BBPS ≥6 (p=0.006), whereas ADR was 16.2% and 26.9%, respectively (p=0.023) (Fig. 3). Detailed comparisons of demo-

Table 3. Segmental and total Boston Bowel Preparation Scale (BBPS) scores (n=1,110)

Variable	Score/Category	Min–Max	Median	Mean±SD / n (%)
Right colon BBPS score	0			23 (2.1%)
	1			119 (10.7%)
	2			533 (48.0%)
	3			435 (39.2%)
Left colon BBPS score	0			9 (0.8%)
	1			30 (2.7%)
	2			300 (27.0%)
	3			771 (69.5%)
Transverse colon BBPS score	0			15 (1.4%)
	1			47 (4.2%)
	2			341 (30.7%)
	3			707 (63.7%)
Total BBPS score		0.0–9.0	8.0	7.5±1.7
Inadequate bowel preparation	<6			105 (9.5%)
Adequate bowel preparation	≥6			1,005 (90.5%)

BBPS: Boston Bowel Preparation Scale; SD. standard deviation.

graphic, clinical, and procedural variables are summarized in Table 4.

Patients with adequate fluid intake had significantly higher total BBPS scores than those with inadequate fluid intake (p=0.001) (Fig. 4). Although the proportion of patients with adequate bowel preparation was higher in the adequate hydration group, this difference did not reach statistical significance (p=0.178). Segment-based analysis demonstrated significantly higher cleansing scores in the right, left, and transverse colon among adequately hydrated patients (p=0.005, p=0.002, and p<0.001, respectively) (Table 5).

Seasonal evaluation showed that total BBPS scores during winter were significantly lower than those observed during the other seasons (all p<0.001). In addition, a significant difference was observed between summer and autumn (p=0.012) (Fig. 5). Adequate bowel cleansing rates differed significantly only between winter and autumn (p=0.029). Segmental assessment further demonstrated that right colon BBPS scores were significantly lower during winter

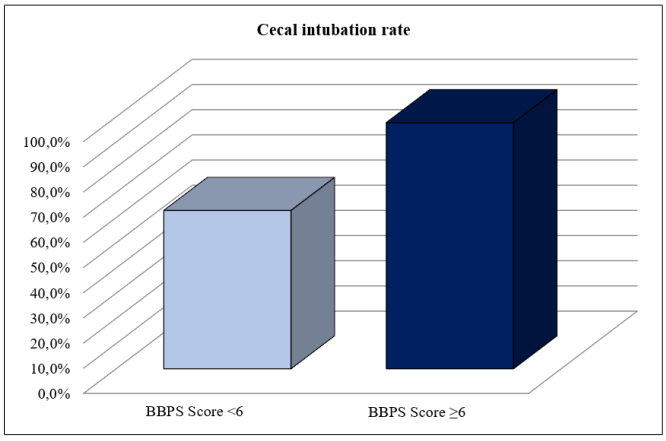

Figure 1. Comparison of cecal intubation rates between patients with inadequate and adequate bowel preparation (Boston Bowel Preparation Scale [BBPS] <6 vs. BBPS ≥6).

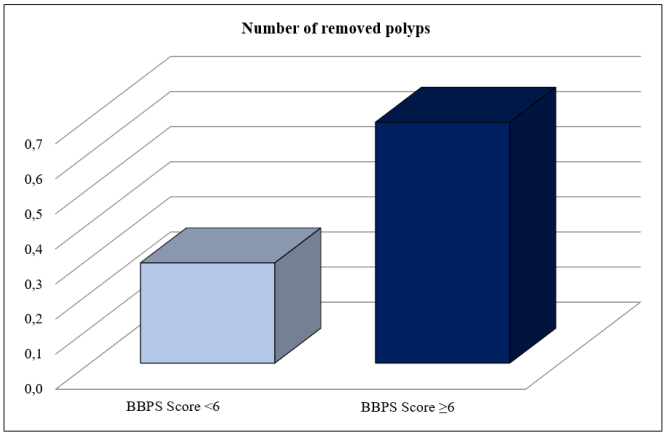

Figure 2. Comparison of the mean number of polyps removed according to bowel preparation adequacy (BBPS <6 vs. BBPS ≥6).

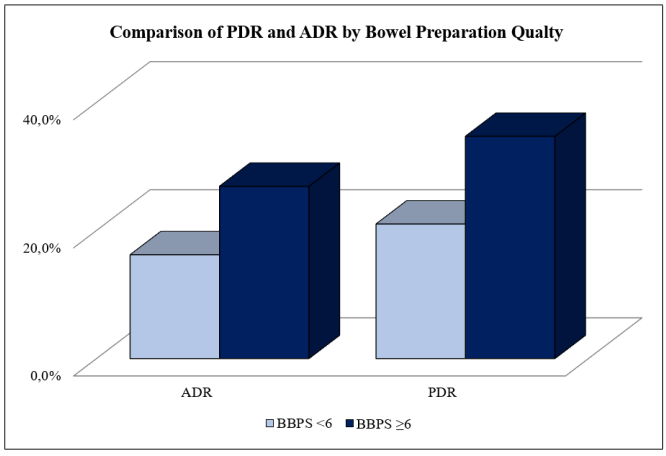

Figure 3. Comparison of the polyp detection rate (PDR) and adenoma detection rate (ADR) according to bowel preparation adequacy (BBPS <6 vs. BBPS ≥6).

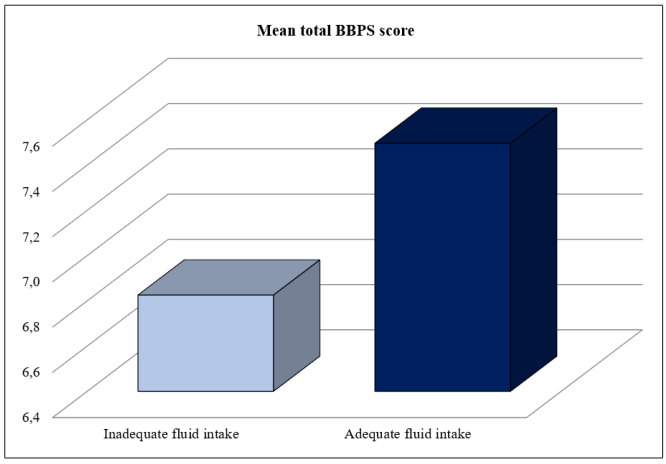

Figure 4. Mean total Boston Bowel Preparation Scale (BBPS) scores in patients with adequate and inadequate fluid intake.

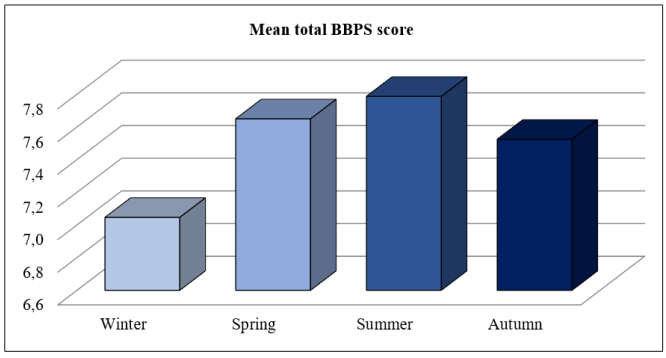

Figure 5. Comparison of mean total BBPS scores across seasons.

than during all other seasons (all p<0.001). Similarly, left colon BBPS scores were significantly lower in winter than in spring, summer, and autumn (p<0.001, p<0.001, and p=0.029, respectively). In addition, significant differences in left colon cleansing were observed between autumn and both summer and spring (p=0.006 and p=0.041, respectively). In the transverse colon, significant differences were observed between winter and spring (p=0.023), winter and summer (p<0.001), and summer and autumn (p=0.05). Seasonal differences in bowel preparation scores are presented in detail in Tables 6 and 7.

Discussion

The patient population evaluated in our study reflects the general population undergoing elective colonoscopy with respect to age, sex distribution, and comorbidity rates. In the literature, the mean age of patients undergoing colonoscopy is typically reported to be between 50 and 60 years, with a similar distribution between males and females.[11]

In our study, the cecal intubation rate was 94.4%, the mean withdrawal time was 6.9 minutes, and the adenoma detection rate (ADR) was 25.9%. These values are consistent with international quality indicators. Current guidelines recommend a cecal intubation rate >90% (95% for screening colonoscopies), a minimum withdrawal time of 6 minutes, and an ADR of approximately 25%.[3,12,13] These findings indicate that our study was conducted in accordance with established quality standards.

The mean Boston Bowel Preparation Scale (BBPS) score in our study was 7.5±1.7, and adequate bowel preparation (BBPS ≥6) was achieved in 90.5% of patients. This rate is consistent with the ≥90% adequacy target recommended by the European Society for Gastrointestinal Endoscopy (ESGE).[13] In the literature, adequate bowel preparation rates are generally reported to range from 75% to 90%.[14,15] The relatively high rate observed in our study may be attributed to good patient compliance and effective implementation of a standardized preparation protocol. In addition, the inclusion of only patients undergoing elective colonoscopy and the exclusion of emergency and hospitalized patients may have contributed to the higher bowel preparation quality. Indeed, previous studies have reported higher rates of inadequate bowel preparation in hospitalized patients and those undergoing emergency colonoscopy.[16,17]

In the segmental analysis, both the proportion of patients with a score of 3 and the proportion with adequate preparation (score ≥2) were lower in the right colon than in the left and transverse colon. This finding suggests that bow-

Table 4. Comparison of demographic, clinical, and procedural characteristics according to bowel preparation adequacy

Variable	Category	BBPS score <6 (n=105), Mean±SD / n (%)	Median	BBPS score ≥6 (n=1,005), Mean±SD / n (%)	Median	p
Age, years		54.8±15.2	56.0	56.1±12.0	57.0	0.586 [m]
Sex	Male	44 (41.9%)		470 (46.8%)		0.342 [X²]
	Female	61 (58.1%)		535 (53.2%)		
BMI		27.6±4.1	27.4	27.8±4.6	27.3	0.869 [m]
Comorbidity		57 (54.3%)		518 (51.5%)		0.592 [X²]
History of abdominal surgery		38 (36.2%)		312 (31.0%)		0.280 [X²]
Smoking		29 (27.6%)		214 (21.3%)		0.136 [X²]
Alcohol consumption		4 (3.8%)		20 (2.0%)		0.223 [X²]
Regular medication use		58 (55.2%)		478 (47.6%)		0.134 [X²]
Anticoagulant use		33 (31.4%)		214 (21.3%)		**0.018** [X²]
Family history of colorectal cancer		17 (16.2%)		157 (15.6%)		0.879 [X²]
Complete bowel preparation medication use	No	6 (5.7%)		23 (2.3%)		**0.036** [X²]
	Yes	99 (94.3%)		982 (97.7%)		
General anesthesia		35 (33.3%)		285 (28.4%)		0.284 [X²]
Cecal intubation		66 (62.9%)		982 (97.7%)		**<0.001** [X²]
Colonoscopy duration, min		14.6±6.7	14.0	15.4±6.7	15.0	0.052 [m]
Withdrawal time, min		5.85±3.10	5.00	6.99±3.84	6.00	**0.001** [m]
Number of polyps removed		0.29±0.63	0.00	0.69±1.37	0.00	**0.002** [m]
Polyp detection rate		22 (21.0%)		349 (34.7%)		**0.006** [X²]
Adenoma detection rate		17 (16.2%)		270 (26.9%)		**0.023** [X²]
Colonoscopy findings	Normal	39 (37.1%)		528 (52.5%)		**<0.001** [X²]
	Abnormal	66 (62.9%)		477 (47.5%)		

ADR: adenoma detection rate; BBPS: Boston Bowel Preparation Scale; BMI: body mass index; PDR: polyp detection rate; SD: standard deviation. [m] Mann-Whitney U test, [X²] Chi-square test.

el cleansing in the right colon may be more challenging than in other segments. Previous studies have similarly reported that right colon cleansing is more difficult and that suboptimal preparation is more frequently observed in this segment.[18,19] Inadequate cleansing of the right colon is clinically important because it increases the risk of missing flat and small lesions.[18,19]

Our study demonstrated that inadequate bowel preparation significantly impairs colonoscopy quality indicators. The lower cecal intubation rate in patients with BBPS <6 indicates that inadequate preparation directly compromises procedural success. In addition, the shorter withdrawal time observed in this group suggests that mucosal evaluation may be limited under suboptimal visualization conditions. Consistent with our findings, previous studies have shown that bowel preparation quality is a key determinant of colonoscopy performance and that inadequate preparation adversely affects both procedural quality and completion rates.[14,20]

One of the most notable findings of our study is the impact of inadequate bowel preparation on lesion detection performance. Both the polyp detection rate (PDR) and ADR

Table 5. Comparison of total and segmental Boston Bowel Preparation Scale scores according to fluid intake adequacy

Variable	Score/Category	Inadequate fluid intake (n=63), Mean±SD / n (%)	Median	Adequate fluid intake (n=1,047), Mean±SD / n (%)	Median	p
Total BBPS score		6.8±1.7	7.0	7.5±1.7	8.0	**0.001** [m]
Total BBPS score	<6	9 (14.3%)		96 (9.2%)		0.178 [X²]
	≥6	54 (85.7%)		951 (90.8%)		
Right colon BBPS score	0	0 (0.0%)		23 (2.2%)		**0.005** [X²]
	1	10 (15.9%)		109 (10.4%)		
	2	39 (61.9%)		494 (47.2%)		
	3	14 (22.2%)		421 (40.2%)		
Left colon BBPS score	0	0 (0.0%)		9 (0.9%)		**0.002** [X²]
	1	3 (4.8%)		27 (2.6%)		
	2	27 (42.9%)		273 (26.1%)		
	3	33 (52.4%)		738 (70.5%)		
Transverse colon BBPS score	0	0 (0.0%)		15 (1.4%)		**<0.001** [X²]
	1	7 (11.1%)		40 (3.8%)		
	2	30 (47.6%)		311 (29.7%)		
	3	26 (41.3%)		681 (65.0%)		

BBPS: Boston Bowel Preparation Scale; SD: standard deviation. [m] Mann-Whitney U test, [X²] Chi-square test.

were significantly lower in patients with BBPS <6. The parallel decrease in PDR and ADR suggests that both polyp and adenoma detection are similarly affected by bowel preparation quality. This finding indicates that bowel cleanliness is a critical factor directly influencing diagnostic accuracy. Previous studies have demonstrated that inadequate bowel preparation increases adenoma miss rates and particularly leads to missed small lesions.[15,21] Furthermore, a decline in colonoscopy quality indicators, especially a reduction in ADR, has been associated with an increased long-term risk of interval colorectal cancer.[11,22]

In our study, patients with adequate fluid intake had significantly higher total BBPS scores, highlighting the important role of hydration in bowel preparation quality. However, the lack of a statistically significant difference in the rate of adequate bowel preparation (BBPS ≥6) suggests that fluid intake may influence the degree of bowel cleansing rather than the binary classification of adequacy. The segmental analysis further supports this finding, as better cleansing was observed in all colonic segments among patients with adequate fluid intake. Previous studies have also reported that sufficient fluid intake improves bowel preparation quality and that inadequate hydration is an important risk factor for suboptimal preparation.[7,23] Adequate fluid intake enhances the effectiveness of bowel preparation solutions by diluting colonic contents and facilitating cleansing.[7,23] These findings suggest that adequate hydration is a simple and modifiable factor that may improve bowel preparation quality, particularly in patients at risk of suboptimal preparation.

Our study demonstrated that bowel preparation quality varies according to season, with significantly lower BBPS scores observed during winter. The presence of this difference across all colonic segments suggests that the seasonal effect is not limited to a specific region but may influence overall bowel cleansing. Although the underlying mechanisms of this seasonal variation are not fully understood, they may be explained by a combination of environmental and behavioral factors. Reduced fluid intake, decreased physical activity, and changes in dietary habits during the winter months may negatively affect bowel cleansing, whereas increased hydration and lighter dietary patterns during the summer may facilitate bowel preparation. Previous studies have shown that fluid

Table 6. Comparison of total and segmental Boston Bowel Preparation Scale scores according to season

Variable	Score/Statistic	Winter (n=347)	Spring (n=231)	Summer (n=244)	Autumn (n=288)	p
Total BBPS score	Mean±SD	7.0±1.8	7.6±1.8	7.8±1.6	7.5±1.5	**<0.001** [K]
	Median	7.0[234]	8.0	8.0	8.0[3]	
Total BBPS score	<6, n (%)	42 (12.1%)	24 (10.4%)	19 (7.8%)	20 (6.9%)	0.112 [X²]
	≥6, n (%)	305 (87.9%)	207 (89.6%)	225 (92.2%)	268 (93.1%)	
Right colon BBPS score	0, n (%)	8 (2.3%)	5 (2.2%)	4 (1.6%)	6 (2.1%)	**<0.001** [X²]
	1, n (%)	59 (17.0%)	20 (8.7%)	21 (8.6%)	19 (6.6%)	
	2, n (%)	192 (55.3%)	101 (43.7%)	103 (42.2%)	137 (47.6%)	
	3, n (%)	88[234] (25.4%)	105 (45.5%)	116 (47.5%)	126 (43.8%)	
Left colon BBPS score	0, n (%)	4 (1.2%)	1 (0.4%)	2 (0.8%)	2 (0.7%)	**<0.001** [X²]
	1, n (%)	9 (2.6%)	11 (4.8%)	5 (2.0%)	5 (1.7%)	
	2, n (%)	127 (36.6%)	43 (18.6%)	45 (18.4%)	85 (29.5%)	
	3, n (%)	207[234] (59.7%)	176 (76.2%)	192 (78.7%)	196[23] (68.1%)	
Transverse colon BBPS score	0, n (%)	6 (1.7%)	3 (1.3%)	3 (1.2%)	3 (1.0%)	**0.005** [X²]
	1, n (%)	21 (6.1%)	9 (3.9%)	6 (2.5%)	11 (3.8%)	
	2, n (%)	127 (36.6%)	61 (26.4%)	57 (23.4%)	96 (33.3%)	
	3, n (%)	193[23] (55.6%)	158 (68.4%)	178 (73.0%)	178[3] (61.8%)	

BBPS: Boston Bowel Preparation Scale; SD: standard deviation. [K]Kruskal-Wallis (Mann-Whitney U test), [X²]Chi-square test. Season groups: 1: Winter; 2: Spring; 3: Summer; 4: Autumn.

Table 7. Post hoc pairwise comparisons of Boston Bowel Preparation Scale scores between seasons

Variable	1–2	1–3	1–4	2–3	2–4	3–4
Total BBPS score	**<0.001**	**<0.001**	**<0.001**	0.736	0.058	**0.012** [K]
Adequate bowel preparation (BBPS ≥6)	0.526	0.089	**0.029**	0.323	0.161	0.710 [X²]
Right colon BBPS score	**<0.001**	**<0.001**	**<0.001**	0.951	0.747	0.551 [X²]
Left colon BBPS score	**<0.001**	**<0.001**	**0.029**	0.515	**0.041**	**0.006** [X²]
Transverse colon BBPS score	**0.023**	**<0.001**	0.309	0.666	0.396	**0.050** [X²]

BBPS: Boston Bowel Preparation Scale. [K]Kruskal-Wallis (Mann-Whitney U test), [X²]Chi-square test. Season groups: 1: Winter; 2: Spring; 3: Summer; 4: Autumn.

intake decreases in winter and increases in summer.[24,25] Similarly, physical activity and walking are more common in summer than in winter.[26,27] Several studies have also demonstrated that walking exercise improves bowel preparation quality before colonoscopy.[28,29] In a study by Shi et al.,[30] bowel preparation was found to be poorer in spring and better in summer, and season was identified as a risk factor for inadequate bowel preparation. However, bowel preparation quality is a multifactorial process influenced by patient compliance, adherence to preparation protocols, and patient education. Therefore, the seasonal differences observed in our study cannot be attributed to a single factor. From a clinical perspective, the present findings suggest that seasonal variation should be considered when planning bowel preparation before colonoscopy. The lower BBPS scores observed during winter indicate that greater attention to patient education, adherence to bowel preparation instructions, and adequate hydration during this season may improve bowel preparation quality and, consequently, colonoscopy performance.

Limitations

This study has several limitations. First, it was conducted at a single center, which may limit the generalizability of the findings. Second, the inclusion of only patients undergoing elective colonoscopy and the exclusion of emergency and hospitalized patients may have contributed to the higher observed bowel preparation quality. In addition, variables such as fluid intake and medication compliance were based on patient self-report, which may have introduced measurement bias. Although a standardized bowel preparation protocol was used, the lack of a split-dose regimen represents another limitation. Finally, the mechanisms underlying seasonal variation were not directly measured, and these findings were interpreted based on observational data.

Conclusion

This study demonstrated that bowel preparation quality exhibits seasonal variation, with the lowest quality observed during winter, and that these differences may influence colonoscopy quality indicators and lesion detection. Inadequate bowel preparation negatively affects both procedural performance and diagnostic accuracy. Adequate fluid intake emerged as a modifiable factor associated with improved bowel preparation quality. Therefore, greater emphasis on patient education and adequate hydration, particularly during the winter months, may improve bowel preparation quality and optimize colonoscopy outcomes.

Disclosures

Ethics Committee Approval: Ethics committee approval was obtained from Bakirköy Dr. Sadi Konuk Training and Research Hospital Non-Interventional Scientific Research Ethics Committee (Approval Number: 2025-02-01, Date: 22.01.2025).

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