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Original Article

The Effect of Intervention for Improving Colonoscopy Quality Is Associated with the Personality Traits of Endoscopists

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Background/Aims: This study investigated whether the personality traits of endoscopists are associated with the effect of interventions for the improvement of colonoscopy quality.

Methods: This prospective, multicenter, single-blind study was performed with 13 endoscopists in three health screening centers over a 12-month period. Quality indicators (QIs), including adenoma detection rate (ADR), polyp detection rate (PDR), and withdrawal time, were measured every 3 months. Consecutive interventions for the improvement of colonoscopy quality were conducted every 3 months, which included the personal notification of QIs, the in-group notification of QIs, and finally a targeted "quality education" session. The personality traits of each endoscopist were evaluated for perfectionism, fear of negative evaluation, and cognitive flexibility after the last QI assessment.

Results: A total of 4,095 colonoscopies were evaluated to measure the QIs of the individual endoscopists for 12 months. The mean ADR, PDR, and withdrawal time of the 13 endoscopists were 32.3%, 47.7%, and 394 seconds at baseline and increased to 39.0%, 55.1%, and 430 seconds by the end of the study (p=0.003, p=0.006, and p=0.004, respectively). Among the three interventions, only quality education significantly improved QIs: ADR, 36.0% to 39.0% (odds ratio, 1.28; 95% confidence interval, 1.01 to 1.63). The improvement of ADR and PDR by education was significantly associated with perfectionism (r=0.617, p=0.033 and r=0.635, p=0.027, respectively) and fear of negative evaluation (r=0.704, p=0.011 and r=0.761, p=0.004, respectively).

Conclusions: Education can improve colonoscopy quality, and its effect size is associated with an endoscopist's personal traits such as perfectionism and fear of negative evaluation (ClinicalTrials.gov Registry NCT03796169). **(Gut Liver 2024;18:265-274)**

Key Words: Colonoscopy; Quality indicators; Intervention; Personality; Perfectionism

INTRODUCTION

Colonoscopy leads to a major reduction in the incidence and mortality of colorectal cancer (CRC).[1-4] However, post-colonoscopy CRCs still account for 9% of all CRCs.[5] Colonoscopy is a highly operator-dependent procedure, and considerable variation can be observed in colonoscopy quality (CQ) according to the endoscopists.[6-8] CQ is associated with the risk of postcolonoscopy CRC and subsequent death. To assess CQ objectively, quality indicators (QIs) have been proposed, such as the adenoma detection rate (ADR), polyp detection rate (PDR), and withdrawal

time (WT).[9-11] ADR has been an independent predictor of the development of interval CRC after screening colonoscopy,[12] and it has been reported that colonoscopy with high ADR decreased the risk of interval cancer by nearly half compared with colonoscopy with low ADR.[6]

Various interventions, including financial incentives, WT monitoring, feedback, and education, have been suggested for improving CQ.[13-17] However, the effect of these interventions showed heterogeneous results.

ADR is also associated with the personalities of endoscopists.[18,19] However, little is known about the association between endoscopists' personality traits and the effect of interventions for CQ improvement. Thus, this study was performed to investigate whether the effect of CQ improvement interventions is dependent on an endoscopist's personality traits and which intervention is most effective.

MATERIALS AND METHODS

1. Study design

This was a prospective, multicenter, single-blind study performed from December 2018 to December 2019. A total of 13 endoscopists were enrolled from three health screening endoscopy centers (Health Promotion Center, Seoul St. Mary's Hospital; Health Screening and Promotion Center, Uijeongbu St. Mary's Hospital; and Health Screening and Promotion Center, St. Vincent Hospital).

The endoscopists were informed in advance that there would be a series of actions for improving CQ in their unit. A total of three interventions were performed every 3 months: personal notification, in-group notification, and quality education (Fig. 1). QIs were assessed four times: baseline, after the first intervention, after the second intervention and after the third intervention. The chiefs of each endoscopy unit were informed that this process was a part of a clinical trial and that their QIs would not be included in the analysis. At the first intervention, which was a personal notification, formal performance reports summarizing individual QIs for 3 months were delivered to each endoscopist via e-mail from the chief of his or her endoscopy unit. Thus, each endoscopist was informed about his or her QIs in comparison with the guidelines of comprehensive recommendations but was not told about the other endoscopists' metrics. At the second intervention, which was an in-group notification via e-mail, endoscopists received not only their own QIs since the first intervention but also the other endoscopists' deidentified data. Thus, endoscopists could determine their ranking among these peers. At the third intervention, the chief of each endoscopy unit conducted a "quality education" session. The instruction included information about the importance of high-quality colonoscopy, key techniques to detect neoplastic polyps (average WT >6 minutes, observation of the proximal sides of folds, additional washing, and careful inspection), methods of detecting flat polyps and distinguishing neoplastic polyps from nonneoplastic polyps, and a review of summarized guidelines, including those of the American Society for Gastrointestinal Endoscopy and the European Society of Gastrointestinal Endoscopy.[9,10]

At the end of the study, the endoscopists were informed that the series of interventions was part of a clinical trial, and informed consent was obtained from all 13 endoscopists. Those who submitted the consent form were evaluated for personality traits using the Almost Perfect Scale-Revised (APS-R), Fear of Negative Evaluation Scale (FNES), and Cognitive Flexibility Inventory (CFI). Copies of these paper questionnaires are provided in the Supplementary Material. This study was approved by the Institutional Review Board of the Catholic University of Korea (IRB number: XC15FIMI0020K).

2. Endoscopists

Only board-certified gastroenterologists who experienced over 1,500 cases of colonoscopies were included in this study. There were a total of 13 endoscopists in three institutions, and all signed the consent and were included the study. One of the participating endoscopists was on maternity leave for 3 months after the second intervention. Because she did not receive the education intervention, the

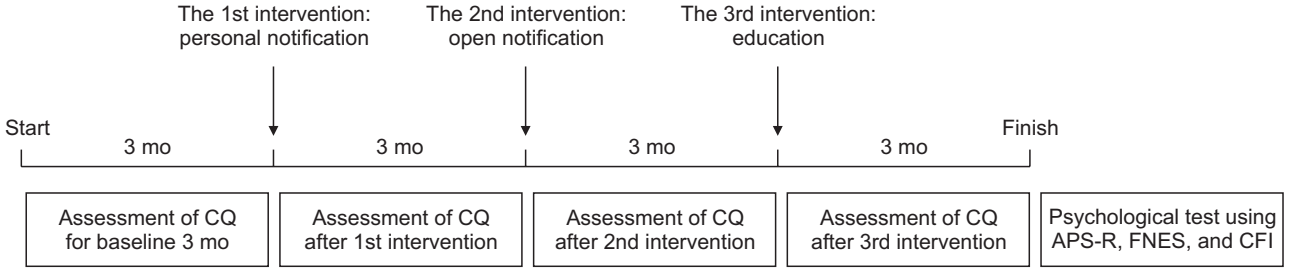


Fig. 1. Flowchart of the study protocol. CQ, colonoscopy quality; APS-R, Almost Perfect Scale-Revised; FNES, Fear of Negative Evaluation Scale; CFI, Cognitive Flexibility Inventory.

effect of her education could not be measured. At the end of the study, she performed personality tests, so her data were used in the first and second intervention analyses.

3. Colonoscopy and quality measures

Colonoscopy screening subjects were asymptomatic adults who were undergoing routine screening colonoscopy. In Korea, subjects can receive colonoscopy at health screening centers whenever they pay a certain fee. Thus, we excluded subjects who had history of screening colonoscopy within 3 years to reduce bias from screening of too short intervals. Colonoscopy was performed using either a CF-H260 or 290 series colonoscope (Olympus, Tokyo, Japan).

We excluded subjects as follows: (1) aged 19 or younger, (2) history of screening colonoscopy within 3 years, (3) previous history of colorectal surgery, inflammatory bowel disease and hereditary polyposis syndrome, and (4) any alarm symptoms, including severe or progressively worsening abdominal pain, unexplained weight loss, unexplained iron deficiency anemia, and overt gastrointestinal bleeding.

Data including subject age, sex, and indication for the procedure were collected. Based on medical records and photo documentation, we obtained factors associated with CQ, including bowel preparation, cecal intubation, polyp type and location. The bowel preparation status was evaluated using the Aronchick bowel preparation scale. If the bowel preparation was poor or inadequate, the colonoscopy was excluded. Cecal intubation was defined as the presence of a photograph of the cecum with an appendiceal orifice and colonoscopy with failed cecal intubation was also excluded.

The ADR was defined as the percentage of patients who had at least one adenoma among those undergoing colonoscopy. The PDR was defined as the percentage of patients who had at least one polyp among those undergoing colonoscopy. The WT was measured as the time from the moment of cecal intubation to the extraction of the colonoscope through the anus, excluding time during the therapeutic maneuver, such as biopsy or polypectomy. The daily numbers of colonoscopies performed by each endoscopist were also collected to balance individual workloads.

4. Personality traits

We assumed that specific personality traits of endoscopists could be associated with baseline CQ and the size of the intervention effect for improving CQ. Three personality traits were selected as follows: perfectionism, fear of negative evaluation (FNE), and cognitive flexibility. Perfectionism means a tendency to set high performance standards and strives for flawlessness.[20-23] A positive aspect of perfectionism is that it motivates people to reach their goals, and they derive pleasure from doing so. The APS-R test was developed to orthogonally measure both adaptive and maladaptive aspects of perfectionism,[24] and the score for the adaptive aspects was included in the study. FNE is a combination of negative cognitive and behavioral factors related to the possibility and experience of social evaluation.[25] FNE is related to apprehension about others' evaluations and distress over their negative evaluations.[26,27] FNES is a commonly used test to assess FNE.[28] Cognitive flexibility is the ability to appropriately adjust one's behavior according to a changing environment.[29,30] Cognitive flexibility allows individuals to work efficiently, to disengage from a previous task, reconfigure a new response set, and implement this new response set to the task at hand. The CFI was developed to be a brief self-report measure of cognitive flexibility.[31] We assessed endoscopists using Korean versions of the APS-R, FNES and CFI to measure perfectionism, FNE and cognitive flexibility, respectively. Korean versions of the APS-R, FNES and CFI were already validated and recognized as reliable measuring instruments of personal traits.[32-34]

5. Statistical analysis

The number of colonoscopies and demographics of subjects for each endoscopist were reported as relative frequency for categorical variables and as mean±standard deviation for continuous variables. To analyze the effect of interventions, we used a generalized linear mixed model for repeated intervention and clustered endoscopists. Generalized linear mixed model protocol for the effect of intervention and personality traits on the outcomes (ADR, PDR, WT) was as follows: (1) effect of intervention: fixed effect for the intervention, random effect intercept and endoscopist; (2) effect of personality traits: fixed effect for the personality traits (APS-R, FNES, CFI), a random effect intercept, endoscopist and intervention. We used a variance component structure for random effects, binomial distribution (logit link function) for ADR and PDR, and normal distribution (identity link function) for WT. The study also adjusted for covariates such as subject age, sex, bowel preparation quality, and workload of endoscopists. The workload was defined as the number of colonoscopies per day for each endoscopist. A large number of colonoscopies exhaust endoscopists and make it difficult for them to perform a proper colonoscopy; thus, workload was used as a covariate. Additionally, the correlation between the size of intervention improvement rates and personality traits was assessed using the Spearman correlation coefficient. To analyze the association between personality traits and the effect of interventions, the endoscopists were divided into

Table 1. Characteristics of the Endoscopists and Patients in Baseline and Postintervention Study Groups

Characteristic	Endoscopist													Total
	A	B	C	D	E	F	G	H	I	J	K	L	M	
Baseline														
No. of colonoscopy	74	85	81	86	75	90	79	228	95	130	69	108	72	1,272
Subjects	62	77	66	72	63	72	66	115	58	66	42	92	46	897
Age, yr	50.9±11.2	52.1±11.6	52.1±10.5	54.1±11.3	51.8±11.9	51.4±11.1	52.6±11.9	48.7±10.3	48.5±11.2	47.2±9.4	55.4±11.7	50.4±9.5	55.0±12.1	51.2±1.1
Male sex	40 (64.5)	43 (55.8)	30 (45.5)	40 (55.6)	33 (52.4)	36 (50.0)	38 (57.6)	76 (66.1)	36 (62.1)	49 (74.2)	23 (54.8)	60 (65.2)	29 (63.0)	533 (59.4)
Workload	3.3±1.9	3.1±1.4	3.6±1.6	3.9±1.5	3.6±1.9	3.8±1.7	5.0±2.4	4.0±1.3	2.4±0.7	2.4±0.8	2.1±1.0	3.1±1.0	2.1±0.8	3.4±1.7
First intervention														
No. of colonoscopy	143	137	153	145	164	127	77	196	152	139	129	144	83	1,789
Subjects	84	92	101	102	103	89	54	114	96	65	51	98	34	1,083
Age, yr	49.7±10.2	51.5±11.7	48.6±11.2	51.3±10.6	49.4±10.3	50.0±10.4	49.0±9.7	47.2±9.9	45.8±9.1	48.0±9.9	49.2±9.4	49.3±9.4	49.9±9.8	49.1±10.3
Male sex	54 (64.3)	50 (54.4)	57 (56.4)	53 (52.0)	51 (49.5)	49 (55.1)	29 (53.7)	86 (75.4)	62 (64.6)	48 (73.9)	30 (58.8)	67 (68.4)	23 (67.7)	659 (60.9)
Workload	4.6±1.5	5.0±1.8	5.1±1.6	4.8±1.4	5.2±1.6	4.9±1.8	5.3±1.7	3.7±1.3	2.8±0.8	2.5±0.7	3.3±1.1	3.2±0.9	2.7±1.0	4.2±1.7
Second intervention														
No. of colonoscopy	140	141	140	161	138	147	45	303	136	137	136	214	132	1,970
Subjects	97	77	89	99	88	103	32	106	69	84	94	147	90	1,175
Age, yr	51.9±10.0	50.5±10.6	50.8±10.3	53.2±10.7	49.7±10.9	52.4±10.7	51.0±10.4	50.3±11.6	49.6±10.8	50.3±10.9	54.0±11.9	46.7±10.1	53.5±12.7	50.9±11.1
Male sex	56 (57.7)	45 (58.4)	43 (48.3)	47 (47.5)	47 (53.4)	53 (51.5)	26 (81.3)	71 (67.0)	41 (59.4)	51 (60.7)	54 (57.5)	109 (74.2)	50 (55.6)	693 (59.0)
Workload	4.7±1.4	4.3±1.3	4.7±1.5	5.0±1.5	4.3±1.4	4.7±1.4	3.9±1.4	5.6±1.4	2.3±0.7	2.1±0.8	2.6±1.0	4.5±1.1	2.8±1.1	4.1±1.6
Third intervention														
No. of colonoscopy	90	74	125	92	130	123		327	154	154	81	141	124	1,615
Subjects	49	48	84	60	79	72	-	128	96	96	56	84	88	940
Age, yr	48.1±10.9	51.9±14.2	50.3±9.4	50.0±9.1	49.5±11.7	49.1±10.5		48.2±10.8	48.8±9.0	49.1±10.2	55.3±12.0	49.4±8.8	56.7±11.7	50.3±10.9
Male sex	28 (57.1)	31 (64.6)	42 (50.0)	27 (45.0)	38 (48.1)	35 (48.6)		87 (68.0)	65 (67.7)	66 (68.8)	30 (53.6)	54 (64.3)	48 (54.6)	551 (51.0)
Workload	3.9±1.2	3.9±1.3	4.4±1.2	4.1±1.6	4.3±0.9	4.4±1.4	-	5.8±1.6	2.9±0.7	3.0±1.1	2.7±1.1	3.5±1.0	2.8±1.1	3.9±1.5

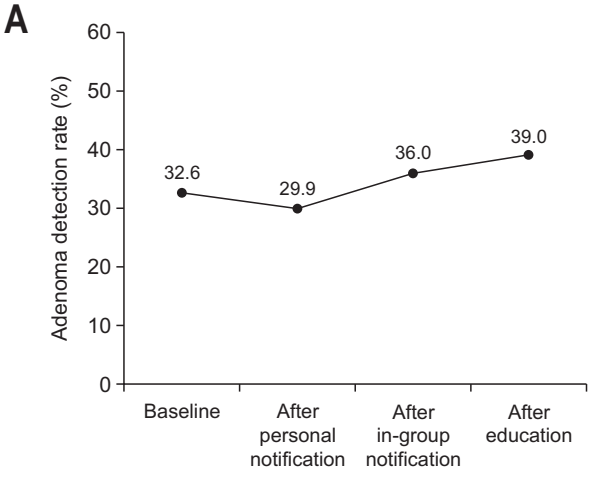
Data are presented as mean±SD or number (%).

a high score group and a low score group with the cutoff at the median value. In previous studies, subjects were classified into high and low groups and compared using median values. Compared to low scorers, high scorers showed more apparent psychological characteristics.[28,32-34] All reported p-values are two-sided, and p-values of less than 0.05 were considered to be significant. Statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC, USA) or R software version 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria; www.r-project.org).

RESULTS

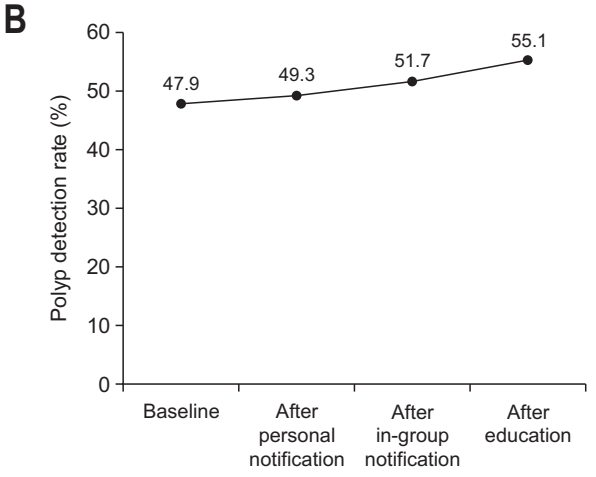
1. Study population

A total of 6,646 colonoscopy were performed in the



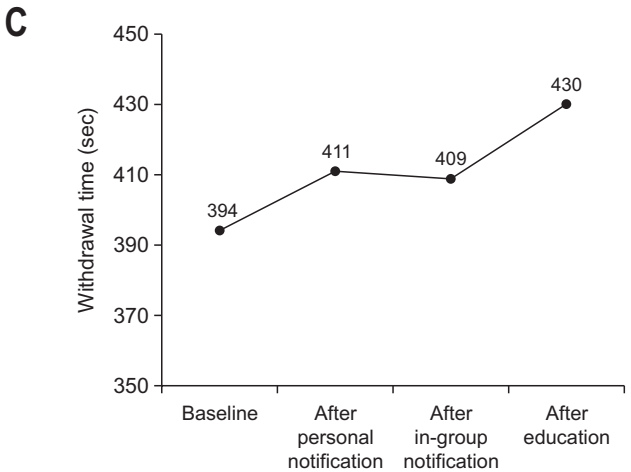
Adjusted OR (95% CI)	Reference	1.02 (0.79–1.31)	1.16 (0.91–1.49)	1.49* (1.15–1.93)

	Adjusted OR (95% CI)
In-group notification vs personal notification	1.14 (0.90–1.44)
Education vs in-group notification	1.28* (1.01–1.63)



Adjusted OR (95% CI)	Reference	1.22 (0.95–1.57)	1.15 (0.90–1.48)	1.46* (1.13–1.89)

	Adjusted OR (95% CI)
In-group notification vs personal notification	0.94 (0.75–1.19)
Education vs in-group notification	1.27† (0.99–1.61)



Adjusted β ± SE (p-value)	Reference	16.8±10.7 (0.125)	5.9±10.6 (0.581)	33.7±11.0 (0.004*)

	Adjusted β ± SE (p-value)
In-group notification vs personal notification	−10.9±10.5 (0.305)
Education vs in-group notification	27.8±10.7 (0.014*)

Fig. 2. Improvement in the colonoscopy quality according to the interventions. (A) Improvement in the adenoma detection rate according to the interventions. (B) Improvement in the polyp detection rate according to the interventions. (C) Improvement in the withdrawal time according to the interventions. Odds ratio (OR) estimates were calculated using a generalized linear mixed model that included physician clustering variables. Analyses were adjusted by age, sex, bowel preparation quality, and workload of the endoscopist. CI, confidence interval. *Statistically significant; †Trend for a statistical significance.

three health screening centers by 13 gastroenterologists, of which 4,095 colonoscopies were analyzed: 897 in the baseline phase, 1,083 after the first intervention, 1,175 after the second intervention, and 940 after the third intervention. The data are detailed in Table 1. Two thousand five hundred and fifty-one colonoscopies were excluded: screening colonoscopy within 3 years (n=1,819), poor or inadequate bowel preparation (n=678), previous colorectal resection (n=19), and failed cecal intubation (n=35).

2. Effect of the interventions for CQ improvement

The overall ADR, PDR, and WT for endoscopists in the baseline phase were 32.6%, 47.9%, and 394 seconds, respectively. After all three interventions, ADR increased to 39.0%, PDR increased to 55.1%, and WT increased to 430 seconds. After adjusting for subject age, sex, bowel preparation quality, and endoscopist workload, the ADR increased 1.49-fold (p=0.003), the PDR increased 1.46-fold (p=0.006) and the WT increased by 33.7 seconds (p=0.004) (Fig. 2).

Among the three interventions, education increased the outcomes of QIs with statistical significance or trend for significance: ADR increased to 39.0% after the third intervention compared with 36.0% after the second intervention (odds ratio [OR], 1.28; 95% confidence interval [CI], 1.01 to 1.63; p=0.041), PDR increased to 55.1% after the third intervention compared with 51.7% after the second intervention (OR, 1.27; 95% CI, 0.99 to 1.61; p=0.057), and WT increased to 430 seconds after the third intervention from 409 seconds after the second intervention (adjusted β±standard error, 27.8±10.7; p=0.014). However, personal notification or in-group notification did not make statistically significant differences in QIs.

3. Effect of interventions associated with personality traits

After education, the improvement rates of ADR and PDR were significantly associated with APS-R (Spearman correlation coefficient [r]=0.617, p=0.033; r=0.635; p=0.027, respectively) and FNES (r=0.704, p=0.011; r=0.761; p=0.004, respectively) (Table 2).

The median APS-R score of 13 endoscopists was 50 (range, 37 to 61). The median FNES score of 13 endoscopists was 36 (range, 19 to 44). The median CFI score was 92 (range, 76 to 113). Endoscopists were divided into high- and low-score groups for the APS-R, FNES and CFI scores with the cutoff at the median value. At baseline, there was no difference in ADR, PDR, or WT among the high and low APS-R, FNES, and CFI groups (Table 3). We also compared the effect of interventions between the high- and low-score groups. Improvements in ADR, PDR, and WT after all interventions were significantly higher in the high APS-R group than in the low APS-R group (Table 4). The ADR increased by 9.3% in the high APS-R group compared with 6.1% in the low APS-R group (OR, 1.46; 95% CI, 1.08 to 1.98; p=0.015). PDR increased by 10.7% in the high APS-R group compared with 6.1% in the low group (OR, 1.40; 95% CI, 1.01 to 1.95; p=0.046). WT increased by 41.3 seconds in the high group compared with 40.8 seconds in the low group (adjusted β±standard error, 51.36±17.24, p=0.003). However, there was no significant improvement in any QI between the high- and low-score groups for FNES and CFI following all interventions.

4. Sensitivity analysis

In our study, one endoscopist revealed very high QIs, especially at baseline (ADR 73.8%, PDR 85.7%, and WT 505 seconds). Due to the unusual baseline measurements, we again analyzed correlations between personality traits, base-

Table 2. Correlation of Intervention Improvement Rates with Personality Traits

Personality	Intervention	With ADR		With PDR		With WT	
		r	p-value	r	p-value	r	p-value
APS-R	Personal notification	–0.183	0.550	–0.119	0.698	–0.235	0.439
	In-group announcement*	0.089	0.773	0.089	0.773	0.366	0.219
	Education	0.617	0.033‡	0.635	0.027‡	–0.113	0.727
FNES	Personal notification	–0.011	0.971	–0.337	0.260	–0.646	0.017
	In-group announcement*	–0.133	0.666	0.039	0.900	0.304	0.313
	Education†	0.704	0.011‡	0.761	0.004‡	–0.120	0.711
CFI	Personal notification	0.149	0.627	0.232	0.446	0.337	0.260
	In-group announcement*	–0.243	0.424	0.072	0.816	0.227	0.457
	Education†	0.317	0.316	0.162	0.615	0.486	0.109

ADR, adenoma detection rate; PDR, polyp detection rate; WT, withdrawal time; APS-R, Almost Perfect Scale-Revised; FNES, Fear of Negative Evaluation Scale; CFI, Cognitive Flexibility Inventory.

*Improvement in colonoscopy quality (CQ) after the second intervention compared with the CQ after the first intervention; †Improvement in CQ after the third intervention compared with CQ after the second intervention; ‡Statistically significant.

Table 3. Baseline Colonoscopy Quality According to the Personality Traits

Personality	Low score group, %	High score group, %	Adjusted OR (95% CI)	p-value
ADR				
APS-R	25.6	39.5	1.93 (0.92–4.08)	0.084
FNES	32.2	32.8	0.96 (0.42–2.24)	0.932
CFI	33.1	32.2	0.88 (0.38–2.03)	0.759
PDR				
APS-R	41.7	54.2	1.72 (0.72–4.11)	0.221
FNES	46.0	49.3	1.05 (0.41–2.64)	0.925
CFI	49.9	46.5	0.73 (0.29–1.81)	0.493
WT, adjusted β±SE				
APS-R	360.5±125.3	426.9±131.7	64.5±38.4	0.094
FNES	395.2±135.0	392.6±131.1	9.1±42.9	0.832
CFI	431.3±128.9	365.9±128.7	−60.9±38.9	0.117

OR, odds ratio; CI, confidence interval; ADR, adenoma detection rate; APS-R, Almost Perfect Scale-Revised; FNES, Fear of Negative Evaluation Scale; CFI, Cognitive Flexibility Inventory; PDR, polyp detection rate; WT, withdrawal time; SE, standard error.

Table 4. Improvement in Colonoscopy Quality According to the Personality Traits after Overall Interventions

Personality	Baseline, %	After overall interventions, %	Adjusted OR (95% CI)	p-value
ADR				
APS-R				0.015*
Low group	25.6	31.7	1	
High group	39.5	48.8	1.46 (1.08–1.98)	
FNES				0.669
Low group	32.2	36.7	1	
High group	32.8	40.6	0.93 (0.67–1.29)	
CFI				0.236
Low group	33.1	39.2	1	
High group	32.2	39.0	0.82 (0.60–1.13)	
PDR				
APS-R				0.046*
Low group	41.7	47.8	1	
High group	54.2	64.9	1.40 (1.01–1.95)	
FNES				0.496
Low group	46.0	52.5	1	
High group	49.3	56.8	0.89 (0.63–1.25)	
CFI				0.083
Low group	49.9	54.6	1	
High group	46.5	55.6	0.74 (0.53–1.04)	
WT, adjusted β±SE				
APS-R				0.003*
Low group	360.5±125.3	401.3±136.8	0	
High group	426.9±131.7	468.2±125.7	51.36±17.24	
FNES				0.378
Low group	395.2±135.0	444.6±117.7	0	
High group	392.6±131.1	420.7±146.1	−16.45±18.65	
CFI				0.002*
Low group	431.3±128.9	446.0±150.8	0	
High group	365.9±128.7	415.5±119.7	53.17±17.11	

OR, odds ratio; CI, confidence interval; ADR, adenoma detection rate; APS-R, Almost Perfect Scale-Revised; FNES, Fear of Negative Evaluation Scale; CFI, Cognitive Flexibility Inventory; PDR, polyp detection rate; WT, withdrawal time; SE, standard error.
p-values were calculated using a generalized linear mixed model for clustered data (cluster endoscopist and repeated intervention). Analyses were adjusted by age, sex, bowel preparation quality total workload, and the workload of the endoscopist; *statistically significant.

line CQ, and effects of intervention on QIs after excluding the endoscopist. However, the analysis of the remaining 12 endoscopists showed similar results, and the outlier did not have any significant impact on the study results.

DISCUSSION

In the present study, we show for the first time that the effect of interventions for improving CQ is significantly associated with the personality traits of endoscopists. There have been many trials aimed at improving CQ; however, simple interventions such as video recording or keeping WT did not show significant improvement in ADR.[35] "Education and feedback" is the most commonly used CQ improvement intervention, but the effect has been controversial. A randomized study involving an educational program showed an ADR increase of up to 47% in the trained group compared to 35% in the untrained group (p=0.0013),[15] while a prospective community-based study reported no significant improvement despite multiple systematic interventions, including feedback on ADR reviews, education, personal discussions and financial consequences.[16] Another randomized trial that performed either an educational program or feedback only for leaders of screening centers showed that a short dedicated educational intervention can induce a greater improvement in ADR than audit and feedback.[36] In our study, ADR and PDR significantly improved after overall interventions from 32.6% to 39.0% and from 47.9% to 55.1%, respectively. WT was also prolonged from 394 seconds to 430 seconds. Analyzing each interventional phase, education was the only intervention to improve QIs with statistical significance or a trend toward significance. Both personal notification and in-group notification increased ADR but did not reach statistical significance, which means that education was more efficient in improving CQ than feedback, and the results were consistent with previous studies.

In the present study, the improvements of ADR and PDR resulting from education were significantly greater in endoscopists with higher perfectionism and FNE. Previous studies have shown that endoscopists' personality may also be associated with CQ. Ezaz *et al.*[19] reported that the ADR was significantly associated with the degree of compulsiveness and perceived thoroughness, which were measured by a self-reported survey. Another study using the Minnesota Multiphasic Personality Inventory-2 showed a weak association between ADR and ego strength (OR, 1.04; p=0.044).[18] In our study, the high perfection group showed an ADR of 39.5% in the baseline phase compared with 25.6% in the low perfection group, although the difference was not statistically significant (p=0.084). However, the difference between the two groups became significant after interventions: the ADR in the high perfection group was 48.8%, and that in the low perfection group was 31.7% (p=0.008). In addition, improvements in ADR, PDR and WT after the overall interventions were significantly higher in the high perfection group than in the low perfection group.

Perfectionism means high personal performance standards with excessive self-criticism for failure to achieve those standards,[21] and both perfectionism and FNE are associated with sociophobia and obsessive-compulsive tendencies. However, perfectionism has two forms, "adaptive perfectionism" and "maladaptive perfectionism," and the former is related to a higher level of endurance and achievement. Individuals with adaptive perfectionism enjoy pursuing their perfectionistic striving, and a previous study showed that adaptive perfectionism in medical students was significantly correlated with higher academic expectations and conscientiousness.[37] In the present study, only the adaptive aspects of perfectionism were calculated for the analyses, thus our results should be interpreted in consideration of the multidimensional aspect of perfectionism.

FNE means the degree to which people experience apprehension at the prospect of being evaluated negatively.[28] Subjects with a higher FNE work harder on boring tasks when they believe the work will be explicitly approved by others[26] and prefer to be in a positive asymmetrical relationship—where they are liked by another more than they like the other individual—rather than a balanced relationship.[38] For experienced endoscopists, adenoma or polyp detection may be tedious, and it is possible that endoscopists with higher FNES work harder for adenoma detection and are more concerned about their relationship with the chief of each endoscopy unit compared to those with lower FNES.

The strengths of our study include that this was a prospective, multicenter, blind trial for endoscopists who were screening real-world populations. Data adjustment for subject age, sex, bowel preparation and workload of endoscopists was performed to minimize study biases.

Our study has limitations. First, each intervention was conducted for the same endoscopists repetitively within a relatively short period of time. Thus, the effect of previous interventions might be accumulated. Second, the tests for personality traits were performed after the final assessment of CQ for blindness of the study. The personality traits of the endoscopists might be changed for the study period or affected by interventions for CQ improvement. Third, only experienced endoscopists were included in this study. Fourth, long-term effects of the interventions were not observed.

In conclusion, quality education significantly increased CQ, and the improvement in CQ was greater in endoscopists with traits of perfectionism and FNE. Without ethical concerns, tailored interventions according to each endoscopist's personality traits may be considered.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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AUTHOR CONTRIBUTIONS

Study concept and design: B.I.L. Data acquisition: H.H.C., B.I.L., Hyun Cho, Y.S.C., K.M.L., S.W.K., Hwang Choi, M.G.C. Data analysis and interpretation: H.H.C., S.Y.S., B.I.L., Hyun Cho. Drafting of the manuscript: H.H.C., S.Y.S. Critical revision of the manuscript for important intellectual content: Y.J., J.M.P., Y.S.C., K.M.L., S.W.K., Hwang Choi, H.S.C., M.G.C. Statistical analysis: H.H.C., S.Y.S. Administrative, technical, or material support; study supervision: B.I.L. Approval of final manuscript: all authors.

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SUPPLEMENTARY MATERIALS

Supplementary materials can be accessed at https://doi.org/10.5009/gnl220280.

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