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Fasting Blood Sugar and Serum Triglyceride as the Risk Factors of Colorectal Adenoma in Korean Population Receiving Screening Colonoscopy

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In several previously reported studies, metabolic syndrome (MS) was found to be associated with colorectal adenomas. While the incidence of colorectal adenoma is growing in Korean population, there are only few studies that examined the association between MS and colorectal adenoma in Korea. The aim of this study was to investigate relationships between prevalence of colorectal adenoma and MS components. We conducted a cross sectional study using data from individuals who had undergone complete colonoscopy for health examinations at the Health Promotion Center of Korea University Medical Center from July 1, 2004 to July 31, 2010. A total of 7481 subjects (4459 males and 3022 females) were included; 1733 subjects with pathologically proven adenoma were assigned to the case group, and other 5748 subjects were assigned to the non-case group. All the participants underwent colonoscopy and received blood biochemical tests (fasting blood sugar [FBS], insulin, lipid profile, hemoglobin, blood urea nitrogen [BUN], creatinine). Univariate analysis showed that the prevalence of colorectal adenoma was higher in individuals with higher blood pressure, body mass index (BMI), total cholesterol (TC), triglyceride (TG), FBS and lower high-density lipoprotein cholesterols (HDL-C) levels, compared to those with low levels. Multiple logistic regression analysis revealed that high levels of BMI (OR 1.17, 95% CI 1.01-1.34, P trend = 0.01), TG (OR 1.27, 95% CI 1.07-1.51, P trend = 0.006), and FBS (OR 1.19 95% CI 1.01-1.40, P trend = 0.05) were significantly associated with prevalence of colorectal adenoma. Subjects with high levels of BMI, TG and FBS have increased prevalence of developing colorectal adenoma in Korea.

Key Words: BMI, Colorectal adenoma, Metabolic syndrome, Triglyceride

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Introduction

Colorectal cancer (CRC) is the third most common cancer and the fourth most frequent cause of cancer death worldwide [1]. However, globally both the incidence of colorectal cancer and deaths due to this cancer has been decreasing recently, probably due to improvements of the lifestyle and more effective colorectal cancer screening. In contrast, the incidence of colorectal cancer and deaths from this tumor are still increasing in Korea. According to a report from the Ministry of Health and Welfare of Korea, colorectal cancer was the second most commonly diagnosed malignancy in 2009 [2].

The rapid increase in the incidence of and death from CRC is considered to be related to adoption of a western diet rich in processed meat, high-fat foods, and refined rapidly digestible carbohydrates [3].

Most CRCs develop through the adenoma–carcinoma sequence, which allows for screening and prevention of CRCs by colonoscopic examination and polypectomy [4-6]. Understanding risk factors for colorectal neoplasm can provide guidance in developing strategies targeted toward its prevention. Several risk factors for colorectal neoplasm have been proposed, including family history of CRCs and polyps, inflammatory bowel disease, cigarette smoking, lack of physical activity, and obesity [7].

Metabolic syndrome (MS) is typically characterized by glucose intolerance, obesity, hypertension, and dyslipidemia. MS and CRC share common risk factors. Clinical characteristics of MS, such as obesity, dyslipidemia, and insulin resistance, have been linked to increased risk of CRC [7-10]. Several studies suggested development of CRC through dysregulation of insulin and insulin-like growth factors (IGFs), the so-called IGF axis, as the underlying mechanism. Other mechanisms that may account for the link between adiposity and CRC risk include inflammation, altered immune response, oxidative stress, as well as disturbances in adipokines, and sex steroids [11]. However, in contrast to CRC, studies that have suggested an association between clinical manifestations of MS and colorectal adenoma have shown considerable heterogeneity [12-17]. Moreover, there are only few studies examining the association between the individual components of MS and colorectal adenoma in Korea [18]. Thus, in the present study, we focused on the association between individual components of MS and colorectal adenoma in a Korean population.

Materials and Methods

Study population

We enrolled a consecutive series of 7481 adult subjects who underwent a voluntary, complete screening colonoscopy at health care unit of Korea University Medical Center Anam Hospital from July 1, 2004 to July 31, 2010. All the participants received blood biochemical tests (fasting blood sugar (FBS), insulin, lipid profile, hemoglobin, blood urea nitrogen (BUN), creatinine). We excluded subjects whose polyps were not histologically confirmed, or those with incomplete colonoscopy or poor results, colorectal cancer, carcinoid tumor, a past history of inflammatory bowel disease, a past history of colorectal cancer, or other malignancies. A total of 7481 subjects (4459 males and 3022 females) were included and divided into either case or non-case group; 1733 subjects with pathologically confirmed colorectal adenomas, such as tubular, villous, or dysplastic adenoma were included in the case group, and 5748 subjects with normal findings or non-neoplasia, such as hyperplastic polyps or non-specific colitis were included in the non-case group. The hospital ethics committee approved this study and we performed according to Helsinki declaration.

Laboratory assessment and Measurements

Hemoglobin was obtained in all subjects by standard laboratory methods (Toshiba 200-FR, Japan). Blood was centrifuged, and plasma was analyzed for levels of BUN, creatinine, triglyceride (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), glucose, C-reactive protein (CRP) (Sysmex XE-5066, USA), and insulin (Gamma-pro, Korea). Low-density lipoprotein cholesterol (LDL-C) was calculated by Friedewald formula. Friedewald formula drives LDL-C from TC, HDL-C, and TG in fasting state: [LDL-C] = [TC] – [HDL-C] – [TG]/5. At the center, height and weight were measured using Inbody 4.0 (Biospace, Korea); height was measured without shoes, to the nearest 0.01 centimeter; and weight was directly measured without shoes and heavy outer garments, to the nearest 0.01 kg. The waist to hip ratio (W/H ratio) and body mass index (BMI) (kg/m^2) for all patients was calculated. Blood pressure (BP) was determined twice by a nurse after a 5-min rest in a sitting position; and the average was taken as the measurement of BP.

Colonoscopy and diagnosis of colorectal adenoma

Complete colonoscopy that reached at least the cecum after bowel preparation with polyethylene glycol was performed. Colonoscopy (Evis Lucera spectrum CLV-260SL Light Source, Olympus, Japan) was performed on each subject by two experienced colonoscopists, who were blinded to the metabolic status of the subjects. The characteristics of the adenoma, including location, number, size, and pathology report were documented. The cecum, ascending colon, and transverse colon were defined as proximal colon, whereas the descending colon, sigmoid colon, and rectum were defined as distal colon. The pathological diagnosis and definition of colorectal adenoma was based on the World Health Organization classification [19]. All specimens were diagnosed with histological descriptions by pathologists.

Definitions

The definition of obesity was BMI ≥ 25 kg/m^2, as recommended by the Korean Ministry of Health and Welfare in 2006 [20]. MS was evaluated as defined by the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III). MS was diagnosed when three or more of the following criteria were met: (1) BMI ≥ 25 kg/m^2; (2) TG ≥ 150 mg/dL, or on drug treatment for elevated TG; (3) HDL-C < 40 mg/dL in males and < 50 mg/dL in females, or on drug treatment for reduced HDL-C; (4) BP ≥ 130/85 mmHg, or on drug treatment for hypertension; and (5) FBS ≥ 110 mg/dL, or on drug treatment for elevated glucose.

Statistical analysis

We compared age, sex, anthropometric measures and biomarkers between adenoma cases and non-cases using a t-test. We used logistic regression models to examine the associations between BMI, insulin, CRP, systolic and diastolic blood pressures, TG, total, HDL-, and LDL-C, and FBS. We grouped SBP (<120, 120-130, 130-140, and >140 mmHg), DBP (<70, 70-80, 80-90, and >90 mmHg) and BMI (<18.5, 18.5-23, 23-25, and >25 kg/m^2) according to diagnostic criteria. We categorized other continuous variables into quartiles. To determine a list of covariates adjusted in the multivariate models, we fitted crude or age-and sex-adjusted models and examined the statistical significance for each variable. We also performed stepwise regression and found that diastolic blood pressure (DBP), TG and total, HDL- and LDL-C were selected at a significance level of 0.1. In the multivariate models, we adjusted for age, sex, DBP, TG, TC and FBS in the multivariate models. We calculated odds ratios (ORs) and 95% confidence intervals (CIs) using the logistic regression model. All statistical analyses were performed using SAS software version 9.3 (SAS Institute Inc., Cary, NC, USA) and p values < 0.05 were considered significant.

Results

General characteristics and blood parameters

Among the case group, there were 1217 (70.23%) males and 516 (29.77%) females. Demographic characteristics and basic measurements, including age, sex, BP, BMI, hemoglobin, TC, HDL-C, TG, FBS, BUN, creatinine, insulin, and CRP are listed in Table 1. As a whole, subjects with colorectal adenomas were older (mean age 53.45 ± 9.38 vs. 49.03 ± 10.45, p < 0.001), had higher blood pressure, BMI, TC, TG, FBS, insulin, CRP, and lower HDL-C levels than those without colorectal adenomas.

Crude and age-sex-adjusted analyses

In crude models, we found higher prevalence of colorectal adenoma with increasing levels of SBP, BMI, TG, TC, FBS, and CRP, and lower prevalence of adenoma with increasing HDL-C. Multiple logistic regression analysis, adjusted for age and sex, revealed that high levels of BMI (OR 1.17 for quartile 4 vs. quartile 1, 95% CI 1.03-1.34, P trend = 0.005), TG (OR 1.27 for quartile 4 vs. quartile 1, 95% CI 1.08-1.49, P trend = 0.004), TC (OR 1.13 for quartile 4 vs. quartile 1, 95% CI 0.97-1.32, P trend = 0.04), and FBS (OR 1.22 for quartile 4 vs. quartile 1, 95% CI 1.03-1.43, P trend = 0.02) were associated with significantly higher prevalence of colorectal adenomas (Table 2). OR for colorectal adenoma increased from the lowest to the highest quartiles in TG in a dose-response way; compared to quartile 1, ORs (95% CIs) were 1.10 (0.99-1.37) for quartile 2, 1.16 (0.99-1.37) for quartile 3, and 1.27 (1.08-1.49) for quartile 4 (P trend = 0.004). For FBS, compared to quartile 1, ORs (95% CIs) were 1.12 (0.95-1.33) for quartile 2, 1.28 (1.09-1.51) for quartile 3, and 1.22 (1.03-1.43) for quartile 4 (P trend = 0.02). However, we found lower prevalence of colorectal adenoma with increasing levels of DBP and LDL-C.

Multivariate analysis adjusted for age, sex, DBP, TC, TG, and FBS

Multivariate logistic regression analysis adjusted for age, sex, DBP, TC, TG and FBS revealed that BMI, TG, and FBS, among the MS components, were significantly associated with higher prevalence of colorectal adenoma (Table 3); comparing quartile 4 to quartile 1, ORs (95% CIs) were 1.17 (1.01-1.34; P trend = 0.01) for BMI, 1.27 (1.07-1.51; P trend = 0.006) for TG, and 1.19 (1.01-1.40; P trend = 0.05) for FBS. We found lower prevalence of colorectal adenoma with increasing levels of DBP, LDL-C and insulin.

Discussion

Our findings support the evidence that BMI, TG and FBS, key components of MS, are associated with prevalence of colorectal adenoma in Korean adults.

Previous studies have found that MS increases the risk of colorectal adenoma by 1.3 to 2 times [13,14,17,21]. In present study, we addressed the positive relationship between

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Table 1. General characteristics of participants according to colorectal adenoma status*

	Normal (n = 5,748)	Adenoma (n =1,733)	p value
Age, yr	49.03 ± 10.45	53.45 ± 9.38	<0.001
Sex, %			<0.001
Men	56.40	70.23	
Women	43.60	29.77	
W/H ratio	0.89 ± 0.05	0.90 ± 0.04	<0.001
Height, cm	164.2 ± 8.61	165.5 ± 8.23	<0.001
Weight, kg	65.18 ± 11.40	67.26 ± 10.69	<0.001
Hemoglobin, g/dL	14.44 ± 1.54	14.76 ± 1.40	<0.001
BUN, mg/dL	12.72 ± 3.33	13.19 ± 3.44	<0.001
Creatinine, mg/dL	0.92 ± 0.19	0.95 ± 0.19	<0.001
Insulin, uIU/mL	8.88 ± 3.99	8.91 ± 5.04	0.85
C-reactive protein, mg/dL	1.49 ± 3.79	1.60 ± 4.26	0.36
Total cholesterol, mg/dL	187.4 ± 32.99	189.6 ± 33.18	0.01
Prevalence of metabolic syndrome, %†	14.90	19.03	<0.001
SBP, mmHg	117.1 ± 13.33	118.8 ± 13.75	<0.001
DBP, mmHg	69.98 ± 10.92	70.54 ± 10.43	0.05
SBP ≥ 130 or DBP ≥ 85 mmHg, %	23.41	30.13	<0.001
BMI, kg/m^2	24.07 ± 3.05	24.48 ± 2.81	<0.001
BMI ≥ 25 kg/m^2, %	35.99	42.57	<0.001
HDL-C, mg/dL	53.52 ± 13.47	51.58 ± 12.70	<0.001
HDL-C < 40 mg/dL in males and HDL-C < 50 mg/dL in female, %	23.08	23.08	>0.99
Triglyceride, mg/dL	131.1 ± 87.64	144.8 ± 95.36	<0.001
Triglyceride ≥ 150 mg/dL, %	28.17	33.66	<0.001
FBS, mg/dL	95.83 ± 18.36	97.99 ± 16.85	<0.001
FBS ≥ 110 mg/dL, %	11.24	14.46	<0.001

W/H ratio: waist to hip ratio, BUN: blood urea nitrogen, SBP: systolic blood pressure, DBP: diastolic blood pressure, BMI: body mass index, HDL-C: high-density lipoprotein cholesterol, FBS: fasting blood sugar.
*Values are presented as mean ± SD unless otherwise indicated; †Metabolic syndrome is diagnosed when three out of the five following: SBP ≥ 130 or DBP ≥ 85 mmHg; BMI ≥ 25 kg/m^2; HDL-C < 40 mg/dL in males and HDL-C < 50 mg/dL in female; triglyceride ≥ 150 mg/dL; FBS ≥ 110 mg/dL.

colorectal adenoma and the components of MS. Recently, it has been shown in several studies that high BMI and TG levels were related to the development of colorectal adenoma [17,21]. Another case-control study reported that only large waist circumference was associated with the development of colorectal adenoma [13]. Consistent with previous reports, this study confirms that high BMI, TG and FBS levels are independent risk factors for colorectal adenoma among the five components of MS in a Korean population.

Although NCEP-ATP III requires waist circumference for diagnosis of MS, we used BMI as an indicator of obesity because the cut-off points of waist circumference in Koreans differ from those currently recommended by the NCEP-ATP III. The cut-off points of waist circumference for central obesity in Koreans are 90 cm for men and 85 cm for women [22]. Moreover, currently there is no equivalent method for the measurement of waist circumstance, whereas BMI is an easy and accurate index. Waist circumference measurements show strong between-observer differences, and should, where possible, be carried out by one observer. Weight and height are the most precisely measured variables, and it is entirely appropriate that they continue to be the predominant measure of choice in

Table 2. Odds ratios (ORs) and 95% confidence intervals (CIs) for colorectal adenoma according to clinical biomarkers

Clinical biomarkers	Categories				P trend
SBP, mmHg	<120	120-130	130-140	>140	
Mean	104.1	120.0	130.0	143.4	
Crude OR (95% CI)	1.00	0.95 (0.84-1.08)	1.38 (1.18-1.61)	1.37 (1.13-1.65)	<0.001
Age-sex adjusted OR (95% CI)	1.00	0.73 (0.64-0.84)	0.95 (0.81-1.12)	0.85 (0.70-1.04)	0.12
DBP, mmHg	<70	70-80	80-90	>90	
Mean	57.2	70.0	80.0	92.0	
Crude OR (95% CI)	1.00	1.14 (1.00-1.30)	1.08 (0.93-1.25)	1.18 (0.94-1.48)	0.17
Age-sex adjusted OR (95% CI)	1.00	0.85 (0.74-0.97)	0.71 (0.60-0.83)	0.75 (0.59-0.95)	<0.001
BMI, kg/m^2	<18.5	18.5-23	23-25	>25	
Mean	17.7	21.3	23.9	27.2	
Crude OR (95% CI)	0.59 (0.36-0.96)	1.00	1.20 (1.04-1.39)	1.41 (1.24-1.61)	<0.001
Age-sex adjusted OR (95% CI)	0.77 (0.46-1.28)	1.00	0.99 (0.85-1.14)	1.17 (1.03-1.34)	0.005
	Quartile 1*	Quartile 2*	Quartile 3*	Quartile 4*	
TG, mg/dL					
Mean	60.7	93.6	133.2	249.1	
Crude OR (95% CI)	1.00	1.28 (1.10-1.51)	1.46 (1.25-1.71)	1.62 (1.39-1.90)	<0.001
Age-sex adjusted OR (95% CI)	1.00	1.10 (0.99-1.37)	1.16 (0.99-1.37)	1.27 (1.08-1.49)	0.004
Total cholesterol, mg/dL					
Mean	147.8	176.2	196.9	231.2	
Crude OR (95% CI)	1.00	0.94 (0.81-1.10)	1.11 (0.96-1.30)	1.21 (1.04-1.41)	0.002
Age-sex adjusted OR (95% CI)	1.00	0.90 (0.77-1.06)	1.03 (0.88-1.21)	1.13 (0.97-1.32)	0.04
HDL-cholesterol, mg/dL					
Mean	38.0	47.5	55.7	70.9	
Crude OR (95% CI)	1.00	0.99 (0.86-1.15)	0.78 (0.67-0.91)	0.73 (0.63-0.85)	<0.001
Age-sex adjusted OR (95% CI)	1.00	1.08 (0.93-1.26)	0.90 (0.77-1.06)	0.94 (0.80-1.10)	0.20
LDL-cholesterol, mg/dL					
Mean	76.9	98.8	116.0	146.2	
Crude OR (95% CI)	1.00	1.07 (0.92-1.24)	1.09 (0.93-1.27)	0.93 (0.80-1.08)	0.32
Age-sex adjusted OR (95% CI)	1.00	0.99 (0.85-1.16)	0.97 (0.82-1.13)	0.79 (0.67-0.92)	0.002
FBS, mg/dL					
Mean	81.7	89.6	96.1	117.3	
Crude OR (95% CI)	1.00	1.23 (1.04-1.45)	1.52 (1.30-1.78)	1.71 (1.46-2.00)	<0.001
Age-sex adjusted OR (95% CI)	1.00	1.12 (0.95-1.33)	1.28 (1.09-1.51)	1.22 (1.03-1.43)	0.02
Insulin, uIU/mL					
Mean	5.1	7.2	9.2	14.0	
Crude OR (95% CI)	1.00	0.88 (0.75-1.03)	0.88 (0.75-1.04)	0.86 (0.73-1.01)	0.10
Age-sex adjusted OR (95% CI)	1.00	0.90 (0.77-1.06)	0.89 (0.76-1.05)	0.87 (0.74-1.02)	0.12
CRP, mg/dL					
Mean	0.2	0.5	1.0	4.4	
Crude OR (95% CI)	1.00	0.98 (0.84-1.16)	1.05 (0.90-1.24)	1.23 (1.05-1.44)	0.002
Age-sex adjusted OR (95% CI)	1.00	0.82 (0.69-0.97)	0.84 (0.71-0.99)	0.96 (0.81-1.13)	0.44

SBP: systolic blood pressure, DBP: diastolic blood pressure, BMI: body mass index, TG: triglyceride, HDL: high-density lipoprotein, LDL: low-density lipoprotein, FBS: fasting blood sugar, CRP: c-reactive protein.

*Quartile cutoff values: TG; 77, 110, 161 mg/dL; total cholesterol; 165, 186, 208 mg/dL; HDL-cholesterol, 43, 51, 60 mg/dL; LDL-cholesterol, 89, 107, 125 mg/dL; FBS; 86, 92, 100 mg/dL; insulin, 6.3, 8.1, 10.6 uIU/ml; CRP; 0.4, 0.7, 1.4 mg/dL.

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Table 3. Multivariate odds ratios (ORs) and 95% confidence intervals (CIs)* for colorectal adenoma according to clinical biomarkers

Clinical biomarkers	Categories				P trend
SBP, mmHg	<120	120-130	130-140	>140	
Mean	104.1	120.0	130.0	143.4	
OR (95% CI)	1.00	0.72 (0.63-0.82)	0.91 (0.77-1.07)	0.81 (0.66-0.99)	0.06
DBP, mmHg	<70	70-80	80-90	>90	
Mean	57.2	70.0	80.0	92.0	
OR (95% CI)	1.00	0.82 (0.72-0.95)	0.68 (0.58-0.79)	0.69 (0.55-0.88)	<0.001
BMI, kg/m^2	<18.5	18.5-23	23-25	>25	
Mean	17.7	21.3	23.9	27.2	
OR (95% CI)	0.79 (0.47-1.32)	1.00	0.98 (0.85-1.14)	1.17 (1.01-1.34)	0.01
	Quartile 1	Quartile 2	Quartile 3	Quartile 4	
Triglyceride, mg/dL					
Mean	60.7	93.6	133.2	249.1	
OR (95% CI)	1.00	1.09 (0.93-1.29)	1.16 (0.98-1.37)	1.27 (1.07-1.51)	0.006
Total cholesterol, mg/dL					
Mean	147.8	176.2	196.9	231.2	
OR (95% CI)	1.00	0.89 (0.76-1.05)	1.01 (0.86-1.18)	1.09 (0.92-1.27)	0.15
HDL-cholesterol, mg/dL					
Mean	38.0	47.5	55.7	70.9	
OR (95% CI)	1.00	1.12 (0.96-1.30)	0.96 (0.81-1.14)	1.04 (0.87-1.24)	0.99
LDL-cholesterol, mg/dL					
Mean	76.9	98.8	116.0	146.2	
OR (95% CI)	1.00	0.97 (0.83-1.13)	0.95 (0.81-1.11)	0.77 (0.66-0.91)	0.002
FBS, mg/dL					
Mean	81.7	89.6	96.1	117.3	
OR (95% CI)	1.00	1.10 (0.93-1.31)	1.26 (1.07-1.48)	1.19 (1.01-1.40)	0.05
Insulin, uIU/mL					
Mean	5.1	7.2	9.2	14.0	
OR (95% CI)	1.00	0.88 (0.75-1.04)	0.85 (0.71-1.00)	0.82 (0.69-0.98)	0.04
C-reactive protein, mg/dL					
Mean	0.2	0.5	1.0	4.4	
OR (95% CI)	1.00	0.81 (0.68-0.96)	0.83 (0.70-0.98)	0.94 (0.80-1.12)	0.50

SBP: systolic blood pressure, DBP: diastolic blood pressure, BMI: body mass index, HDL: high-density lipoprotein, LDL: low-density lipoprotein, FBS: fasting blood sugar.

*Adjusted for age (continuous), sex (male and female), DBP (<70, 70-80, 80-90, and >90), total cholesterol (quartiles), triglyceride (quartiles), and FBS (quartiles). DBP, total cholesterol, triglyceride and FBS were not adjusted when these biomarkers were examined as the main exposures.

the vast majority of nutritional anthropometric studies [23]. Therefore, most medical institutions in Korea use BMI as an indicator of obesity, defined by The Korean Ministry of Health and Welfare as BMI ≥ 25 kg/m^2 [20]. BMI reflects total body fatness, which is associated with insulin resistance and higher level of circulating IGF-1.

The possible mechanisms by which colorectal neoplasms arise in subjects with MS comprise inflammation, insulin resistance and oxidative stress [24]. Adipose tissue is now recognized as an endocrine organ rather than a simple fat storage site, and a wide range of inflammatory cytokines is released from adipose tissue, including CRP, tumor necrosis factor-α

and interleukin-6 [25,26]. Adipose tissue can produce and release the inflammatory cytokines that are potentially procarcinogenic. The association of colorectal adenoma and the inflammatory cytokines has been postulated [27-29]. A previous study has suggested that elevated CRP, a widely used marker of inflammation, is associated with increased risk of colorectal neoplasia in men [30]. In the present study we examined the association between CRP level and colorectal adenoma. However the logistic analysis in this study did not reveal any definite relation between CRP and colorectal adenoma.

Colorectal polyps are common in Western countries; they are found in >30% of autopsies performed in people aged >60 yr [31]. There have been many reports on risk factors of colorectal adenomas in Western countries. Several studies found the association of BMI with increased risk of colorectal adenomas [32,33]. Among the lipid profile, a higher level of serum TG was associated with an increased risk of adenomatous polyps [34]. On the other hand, association of serum cholesterol with colorectal adenoma is still controversial [34,35]. Insulin resistance and diabetes mellitus have been associated with an increased risk of colorectal adenomas in numerous studies [36]. These results are consistent with our study.

There were several limitations to the present study. First, the information on cigarette smoking, alcohol drinking and physical activity was not reported. Lifestyle factors also have been shown to be associated with the incidence of colorectal adenoma [33,37-39]. Second, information on detailed personal medical histories, including hypertension, diabetes mellitus, hyperlipidemia, and current medication was not reported. The possibility of reverse causation due to changes in lifestyle among those with these diseases may partly explain our findings of inverse associations for DBP, LDL-C, and insulin. Third, family history of CRC, which could be a strong risk factor for colorectal cancer, was not included. Finally, the study population was a single center cross sectional study and therefore the results of our study may not infer temporal relationship and may not be generalizable to whole Korean adult population.

Conclusion

This study shows that among the components of MS, high BMI, TG and FBS levels are positively associated with colorectal adenoma in Korean population. Individuals with high BMI, TG, or FBS may be advised to have colonoscopy to prevent CRC. MS should be considered as an important risk factor for colorectal adenoma, especially when high BMI, TG or FBS is present.

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