Published OnlineFirst June 5, 2017; DOI: 10.1158/1940-6207.CAPR-17-0065

Research Article

Cancer Prevention Research

The Effects of Physical Activity and Body Fat Mass on Colorectal Polyp Recurrence in Patients with Previous Colorectal Cancer

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Abstract

We aimed to identify the effects of physical activity and body composition on colorectal polyp recurrence in patients with previous colorectal cancer. A total of 300 patients were selected randomly from the colorectal cancer survivor cohort of Severance Hospital (Seoul, Korea). Patients reported various recreational physical activities and received surveillance colonoscopy. Body composition was measured with a body composition analyzer. We compared patients who exercised for at least 1 hour/week (active) with those who exercised less frequently or not at all (sedentary). The active exercise group ($n = 203$) had a lower recurrence of advanced adenoma than the sedentary group ($n = 97$; 6.4% vs. 14.4%, $P = 0.023$). The prevalence of advanced adenoma recurrence decreased in an exercise dose-dependent manner ($P_{trend} = 0.019$). In multivariate logistic analysis, the independent factors associated with advanced polyp recurrence were body fat mass [OR, 7.601; 95% confidence interval (CI), 1.583–36.485; $P = 0.011$] and active exercise (OR, 0.340; 95% CI, 0.143–0.809; $P = 0.015$). In Cox proportional hazards models, body fat mass (HR, 5.315; 95% CI, 1.173–24.083; $P = 0.030$) and active exercise (HR, 0.367; 95% CI, 0.162–0.833; $P = 0.017$) were the independent factors associated with cumulative advanced adenoma recurrence. In conclusion, exercising for at least 1 hour/week and low body fat mass were found to be related to lower rates of colorectal polyp recurrence in the surveillance of colorectal cancer survivors. *Cancer Prev Res; 10(8); 1–7. ©2017 AACR.*

Introduction

Colorectal cancer is a disease of great prevalence and with increasing incidence worldwide (1, 2). In particular, in combination with a Western diet, aging, lifestyle, and increasing colonoscopy health checkup, prevention of colorectal cancer is receiving large attention (3). Especially, for the primary prevention of colorectal cancer, interest on obesity and physical activity is increasing. Obesity increases the risk of various tumors, such as esophageal cancer, thyroid cancer, gallbladder cancer, pancreatic cancer, colorectal cancer, and colorectal polyps (4). Furthermore, obesity might also be associated with worse cancer outcomes, such as recurrence of primary cancer or mortality (5, 6). In addition, in previous studies, physical activity was associated with a significantly decreased risk of colorectal cancer [OR, 0.76; 95% confidence interval (CI), 0.71–0.82; ref. 7] and colorectal adenoma (OR, 0.84; 95% CI, 0.77–0.92; ref. 8), as well as reduced cancer recurrence and mortality in patients with colorectal cancer (9–12).

The biological mechanisms underlying the relationship between obesity and cancer are complex and not well understood (13). Obesity disrupts the dynamic role of adipocytes in energy homeostasis, resulting in inflammation and alteration of adipokine signaling. Moreover, obesity causes secondary changes that are related to insulin signaling and lipid deregulation that may also foster cancer development (14). Among the signaling pathways linking obesity and cancer, the PI3K/Akt/mTOR cascade, which is a target of obesity-associated factors and regulates cell proliferation and survival, plays a key role (15). Physical activity was associated with a decrease of tumor growth–inducing factors, such as insulin, insulin resistance, insulin-like growth factor-1, or leptin. Physical activity can also decrease the colon transit time and, thus, the contact time of alimentary carcinogens with the colon mucosa (16). In addition, exercise can alter biological processes that contribute to tumor initiation and progression in the carcinogenesis process (17).

Polyp history, patient age, polyp location, obesity, and number, size, and histology of resected polyps were identified as the risk factors of polyp recurrence (18, 19). However, there are few studies on the relationship between colorectal polyp recurrence and physical activity. Lisa and colleagues showed that physical activity, regardless of intensity, is not associated with a reduced risk of polyp recurrence in both men and women (20). In addition, concerning obesity, further analysis based on more detailed measurement of body composition, particularly assessment of fat, would be needed instead of using body mass index (BMI) based on only weight and height.

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Note: Supplementary data for this article are available at Cancer Prevention Research Online (http://cancerprevres.aacrjournals.org/).

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doi: 10.1158/1940-6207.CAPR-17-0065

Published OnlineFirst June 5, 2017; DOI: 10.1158/1940-6207.CAPR-17-0065

To our knowledge, few studies have evaluated the effects of physical activity and body composition on polyp recurrence in detail for a long-term surveillance period. In this study, we aimed to evaluate the effects of physical activity and body fat mass on colorectal polyp recurrence, by using long-term surveillance follow-up data of colorectal cancer survivors.

Materials and Methods

Patients

A total of 300 patients were randomly selected from the colorectal cancer survivor cohort of Severance Hospital (Seoul, Korea). These patients were followed-up for >5 years after the diagnosis and treatment of colorectal cancer. After the curative resection of colorectal cancer, all patients underwent surveillance colonoscopy by experienced endoscopists. All patients underwent a baseline colonoscopy before colorectal resection or within 6 months after colorectal resection. In cases of incomplete colonoscopy before surgery, additional colonoscopic examinations were carried out within 6 months after the operation, and the findings were included as part of the baseline colonoscopic findings. We excised all polyps detected during preoperative and postoperative colonoscopies, and all specimens were sent to the Department of Pathology for histologic evaluation. Follow-up colonoscopy was performed from one to four times per patient, based on the guideline (21). Moreover, to overcome interval diversities of surveillance colonoscopy, we investigated the total follow-up period and the timing of follow-up colonoscopy. The exclusion criteria were as follows: (i) incomplete medical records, (ii) history of familial polyposis syndrome or Lynch syndrome, (iii) known inflammatory bowel disease, and (iv) incomplete baseline colonoscopy before colorectal resection or within 6 months after operation. Cases of incomplete colonoscopy (non-visualized cecum and/or inadequate bowel preparation) were also excluded.

Patients were identified using the electronic medical record system that includes all patients with cancer at Severance Hospital, Yonsei University College of Medicine (Seoul, Korea). This study was approved by the Institutional Review Board of Severance Hospital, Yonsei University.

Data collection

We retrospectively examined and collected the following data from the electronic medical records of the patients: sex; age; education status; smoking and alcohol consumption; comorbidities such as hypertension, diabetes mellitus, and dyslipidemia; and tumor characteristics including tumor location, TNM stage, and grade of cancer differentiation. To evaluate the severity of obesity, we measured the weight, height, BMI, and waist circumference, and used InBody 720 (Biospace) for body composition analysis. InBody 720 can automatically measure various parameters, including BMI, intracellular and extracellular water, body fat mass, protein, and body cell mass. It is noninvasive, can provide an estimation in only a few minutes, and does not need to take into account racial differences (22). For obesity, we followed the World Health Organization (WHO) Asia-Pacific classification to define the categories as normal (BMI < 23.0), overweight (23 ≤ BMI < 25), and obese (BMI ≥ 25; ref. 23). Concerning colorectal adenoma characteristics, we analyzed the number, size, location, and pathology of colorectal polyps (24). The proximal colon includes the cecum, ascending colon, and transverse colon, and the distal colon includes the descending and sigmoid colon. Any detected colorectal adenoma during surveillance colonoscopy was defined as recurrent adenoma. We defined advanced adenoma as an adenoma of size ≥10 mm, histologic finding of villous component, high-grade dysplasia, or serrated adenoma (25).

Physical activity assessment

Physical activity data were collected through the interviewer-administered Global Physical Activity Questionnaire (GPAQ). GPAQ is a survey developed by WHO to evaluate physical activity and includes 16 questions involving activity at work, travel to and from places, recreational activity, and sedentary behavior (26). In this study, we defined patients who exercise at least 1 hour/week as the active exercise group and those who exercise <1 hour/week or not at all as the sedentary group (27).

Statistical analyses

Means and SDs, or medians and ranges were calculated for all continuous variables, as appropriate. Categorical variables were expressed as proportions (%), and statistical analyses were performed to compare the groups of variables. Independent-sample t tests (or Mann–Whitney test) were used to compare continuous variables, and χ^2 tests (or Fisher exact test) were used for categorical variables, as appropriate. Multivariate logistic regression analyses were carried out to identify the independent risk factors of advanced adenoma recurrence with adjustment for various confounders, including age, sex, history of alcohol, smoking, family history of colorectal cancer, diabetes mellitus, hypertension, skeletal muscle mass, body fat mass, active exercise, follow-up duration, time to surveillance colonoscopy, and number of surveillance colonoscopy. Kaplan–Meier analyses (log-rank tests) were carried out to compare the cumulative risk of advanced adenoma development between the active exercise group and the sedentary group. Cox proportional hazards analyses were carried out to reveal the independent risk factors of cumulative development of advanced adenoma with adjustment for the same various confounders. All statistical analyses were assessed with the Statistical Package for Social Sciences (SPSS version 20.0; SPSS Inc.). A P value of <0.05 was considered statistically significant.

Results

Baseline characteristics

A total of 300 patients who were diagnosed as having colorectal cancer and survived >5 years after curative surgical resection were enrolled in this study. Concerning physical activity, 203 patients (67.7%) exercised at least 1 hour/week and were included as the active exercise group. The other 97 (32.3%) patients were categorized as the sedentary group. Between the two groups, there was no significant difference in sex, education status, tumor location, tumor stage, tumor grade, family history of colorectal cancer, hypertension, diabetes mellitus, dyslipidemia, alcohol use, and tobacco use (Table 1). In addition, the time interval from cancer diagnosis to physical activity measurement was not different between the two groups (6.2 ± 1.4 years vs. 6.0 ± 1.3 years, $P = 0.277$). However, patients in the active exercise group were younger (60.6 ± 9.7 years vs. 61.1 ± 12.5 years, $P = 0.004$) and had lower weight (64.1 ± 10.8 kg vs. 64.3 ± 9.0 kg, $P = 0.010$), lower BMI (24.3 ± 2.8 kg/m^2 vs. 24.8 ± 3.6 kg/m^2, $P = 0.006$), and lower waist circumference (86.4 ± 7.7 cm vs. 88.1 ± 9.9 cm,

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Table 1. Baseline characteristics

Variables	Total ($N = 300$)	Sedentary ($n = 97$)	Active ($n = 203$)	P^a
Age (years)	60.9 ± 10.7	61.6 ± 12.5	60.6 ± 9.7	0.004
Males	158 (52.7%)	46 (47.4%)	112 (55.2%)	0.209
Education				0.436
Less than high school	70 (23.3%)	26 (26.8%)	44 (21.7%)	
High school graduate	163 (54.3%)	53 (54.6%)	110 (54.2%)	
College degree or higher	67 (22.3%)	18 (18.6%)	49 (24.1%)	
Tumor location				0.614
Colon	170 (56.7%)	52 (53.6%)	117 (58.1%)	
Rectum	130 (43.3%)	45 (46.4%)	85 (41.9%)	
Invasion through bowel wall				0.785
T1-2	167 (55.7%)	52 (53.6%)	115 (56.7%)	
T3-4	133 (44.3%)	45 (46.4%)	88 (43.3%)	
No. of positive lymph nodes				0.617
N1	275 (91.7%)	90 (92.8%)	185 (91.1%)	
N2	25 (8.3%)	7 (7.2%)	18 (8.7%)	
Grade of differentiation				0.183
Well	76 (25.3%)	32 (33.0%)	44 (21.7%)	
Moderate	200 (66.7%)	60 (61.9%)	140 (69.0%)	
Poor/undifferentiated	14 (4.7%)	5 (5.2%)	9 (4.4%)	
Weight (kg)	64.2 ± 9.6	64.3 ± 9.0	64.1 ± 10.8	0.010
BMI (kg/m^2)	24.5 ± 3.1	24.8 ± 3.6	24.3 ± 2.8	0.006
Waist (cm)	86.9 ± 8.5	88.1 ± 9.9	86.4 ± 7.7	0.008
Skeletal muscle mass (kg)	24.9 ± 5.0	24.2 ± 5.2	25.2 ± 4.9	0.689
Body fat mass (kg)	18.5 ± 6.6	18.9 ± 7.2	18.3 ± 6.3	0.436
Percent body fat (%)	28.6 ± 8.6	29.5 ± 9.2	28.2 ± 8.3	0.471
Visceral fat area (cm^2)	87.9 ± 37.7	91.5 ± 39.9	86.3 ± 36.6	0.496
Body cell mass (kg)	29.5 ± 5.6	28.8 ± 6.3	29.7 ± 5.3	0.156
Family history of CRC	41 (13.7%)	14 (14.4%)	27 (13.3%)	0.789
Hypertension	99 (33.0%)	35 (36.1%)	64 (31.5%)	0.433
DM	51 (17.0%)	21 (21.6%)	30 (14.8%)	0.138
Dyslipidemia	46 (15.3%)	16 (16.5%)	30 (14.8%)	0.700
Current alcohol	153 (51.0%)	47 (48.5%)	106 (52.2%)	0.542
Current tobacco	121 (40.3%)	35 (36.1%)	86 (42.4%)	0.384

NOTE: Variables are expressed as mean ± SD or *n* (%).
Abbreviations: CRC, colorectal cancer; DM, diabetes mellitus.
^{a}*P* value for comparing sedentary and active exercise groups.

$P = 0.008$) than those in the sedentary group, although the difference of the average value was small.

Colonoscopic surveillance

The mean follow-up period was 8.0 years (median, 7 years; range, 5–21 years). The colonoscope was completely inserted into the cecum in all 300 patients. The mean duration between colorectal cancer operation and polyp recurrence was 45.2 months (median, 48 months; range, 6–204 months). Sixty-one patients (20.3%) received one follow-up colonoscopy, 136 (45.3%) received two, 86 (28.7%) received three, and 17 (5.7%) received four or more follow-up colonoscopies. The number of follow-up colonoscopies was not significantly different between the two groups ($P = 0.752$). There was also no significant difference in the interval to the first follow-up colonoscopy (17.0 months vs. 17.0 months, $P = 0.817$; Supplementary Data S1).

Adenoma and advanced adenoma recurrence

A total of 162 (54.0%) patients showed one or more colorectal polyps. The total adenoma recurrence rate was 32.3%, and the total advanced adenoma recurrence rate was 9.0%. The tubular adenoma recurrence rate was 22.7% in the proximal colon and 14.3% in the distal colon and rectum. The advanced adenoma recurrence rate was 6.3% in the proximal colon and 3.3% in the distal colon and rectum.

Physical activity, obesity, body fat mass, and adenoma recurrence

The active exercise group showed a significantly lower recurrence rate of advanced adenoma than the sedentary group (6.4% vs. 14.4%, $P = 0.023$; Table 2). However, no significant difference was found in the total adenoma recurrence rate between the two groups (33.5% vs. 29.9%, $P = 0.533$). When we further categorized the weekly exercise hours by <1, 1 to 3, 3 to 5, and >5 hours, the advanced adenoma recurrence rate significantly decreased as the exercise hours increased: 14.3% for the category <1 hour/week, 8.2% for 1 to 3 hours/week, 9.3% for 3 to 5 hours/week, and 4.5% for >5 hours/week ($P_{trend} = 0.019$; Supplementary Data S2).

In terms of BMI, the patients were divided into normal (94, 31.3%), overweight (83, 27.7%), and obese (123, 41.0%) groups. The recurrence rate of advanced adenoma for each group was 4.3%, 8.4%, and 13.0%, respectively, with significant increase

Table 2. Comparison of colorectal polyp recurrence rate between the sedentary and active exercise group

	Sedentary ($n = 97$)	Active ($n = 203$)	P^a
Any polyp	56 (57.7)	106 (52.2)	0.37
Hyperplastic polyp	23 (23.7)	37 (18.2)	0.267
Tubular adenoma	29 (29.9)	68 (33.5)	0.533
Advanced adenoma	14 (14.4)	13 (6.4)	0.023

NOTE: Variables are expressed as *n* (%).
^{a}*P* value for comparing sedentary and active exercise groups.

Table 3. The risk of colorectal polyp recurrence by baseline BMI, and age- and sex-adjusted logistic regression analysis for polyp recurrence according to BMI

	Polyps		Hyperplastic polyp		Tubular adenoma		Advanced adenoma	
BMI[a] (kg/m^2)	n (%)	RR (95% CI)	n (%)	RR (95% CI)	n (%)	RR (95% CI)	n (%)	RR (95% CI)
Normal (BMI < 23; $n = 94$)	47 (50.0)	1 (reference)	16 (17.0)	1 (reference)	31 (33.0)	1 (reference)	4 (4.3)	1 (reference)
Overweight ($23 \leq$ BMI <25; $n = 83$)	43 (51.8)	1.075 (0.596–1.941)	17 (20.5)	1.256 (0.589–2.678)	27 (32.5)	0.980 (0.522–1.838)	7 (8.4)	2.072 (0.584–7.349)
Obese (BMI $\geq$ 25; $n = 123$)	72 (58.5)	1.412 (0.822–2.424)	27 (22.0)	1.371 (0.690–2.725)	39 (31.7)	0.944 (0.532–1.675)	16 (13.0)	3.364 (1.086–10.425)
P_{trend}		0.410		0.375		0.841		0.025

[a]Adjusted for age and sex.

($P_{trend} = 0.025$; Table 3). Furthermore, the age- and sex-adjusted logistic regression test showed that the obese group also had a greater risk of advanced adenoma than the normal group (RR, 3.364; 95% CI, 1.086–10.452; Table 3).

Multivariate logistic analysis including various confounders, such as age, sex, history of alcohol and smoking, family history of colorectal cancer, diabetes mellitus, hypertension, skeletal muscle mass, body fat mass, active exercise, follow-up duration, time to surveillance colonoscopy, and number of surveillance colonoscopy, was performed to determine the independent factors associated with the development of advanced adenoma. Among the factors, more than normal body fat mass (OR, 7.601; 95% CI, 1.583–36.485; $P = 0.011$) and $\geq$1-hour weekly exercise (OR, 0.340; 95% CI, 0.143–0.809; $P = 0.015$) were independent factors associated with the development of advanced adenoma. Although increased number of surveillance colonoscopy (OR, 2.767; 95% CI, 1.095–6.990; $P = 0.031$) was also found to be one of the independent factors, this should be interpreted on the basis of the fact that more surveillance colonoscopies were performed for advanced adenoma, following the guideline for colonoscopy surveillance after polypectomy (Table 4).

We also performed Kaplan–Meier analysis (log-rank tests) to compare the cumulative rate of development of advanced adenoma between the active exercise and sedentary groups, and between the normal or less and the more than normal body fat mass groups (Fig. 1A and B). Increased body fat mass and sedentary lifestyle were found to be associated with the development of advanced adenoma. Subsequently, multivariate Cox proportional hazards analysis, including the same confounders, also showed that more than normal body fat mass (HR, 5.315; 95% CI, 1.173–24.083; $P = 0.030$) increased the risk of advanced adenoma development, and active exercise (HR, 0.367; 95% CI, 0.162–0.833; $P = 0.017$) decreased the risk (Table 5).

Table 4. Multivariate logistic regression analysis for advanced adenoma recurrence

Variables	OR (95% CI)	P[a]
Age (years)	0.988 (0.946–1.032)	0.590
Male sex	2.012 (0.457–8.857)	0.355
History of alcohol	0.884 (0.195–4.008)	0.873
History of smoking	0.897 (0.203–3.969)	0.886
Family history of colorectal cancer	1.140 (0.276–4.705)	0.856
Hypertension	2.084 (0.742–5.850)	0.163
DM	0.850 (0.278–2.595)	0.775
Skeletal muscle mass (kg)	0.316 (0.036–2.772)	0.299
Body fat mass (kg)	7.601 (1.583–36.485)	0.011
Active exercise (vs. sedentary)	0.340 (0.143–0.809)	0.015
Follow-up duration (years)	1.135 (0.948–1.359)	0.167
Time to first surveillance colonoscopy (months)	1.004 (0.970–1.039)	0.830
Number of surveillance colonoscopy	2.767 (1.095–6.990)	0.031

Abbreviation: DM, diabetes mellitus.

[a]P value for comparing advanced adenoma group and nonadvanced adenoma group.

In addition, we performed subgroup analysis according to body fat mass and exercise amount. In the more than normal body fat mass group, 11 (8.7%) and 14 (23.3%) advanced adenomas were found in 126 patients in the active exercise group and 60 patients in the sedentary group, respectively. This suggests that active exercise in patients with increased body fat mass showed the most significant preventive effect on the development of advanced adenoma ($P = 0.006$; Supplementary Data S3).

Discussion

The important fundamental concept of colorectal cancer development is the "adenoma–carcinoma sequence." This is the carcinogenesis pathway of normal mucosa involving accumulation of genetic mutations and epigenetic changes, transformation to an adenomatous colorectal polyp, and eventually transformation to colorectal cancer, in a stepwise progression (28, 29). Many studies have shown that endoscopic removal of colorectal polyps prevents colorectal cancer, and their results support the sequence pathway (30, 31). Thus, patients who receive treatment of colorectal neoplasia are a high-risk group for colorectal neoplasia development and recommended to receive regular surveillance colonoscopy (32–35).

A history of colorectal cancer itself is a very strong risk factor for the recurrence of advanced adenoma, and many studies have investigated the risk factors of polyp recurrence in patients with colorectal cancer (24, 36). Age, sex, family history of colorectal cancer, and obesity were mentioned as the risk factors of colorectal neoplasia recurrence (9). However, data about the effects of physical activity and body composition on polyp recurrence are relatively not well known. Lisa and colleagues reported that recent physical activity is not associated with polyp recurrence in a 3-year period. However, the methodologic part of the measurement of physical activity amount and the short duration of follow-up period were pointed out as weak points (20). Christine and colleagues showed that sedentary behavior significantly increases colorectal adenoma recurrence in men (37). However, they found an association in men but not in women. Moreover, no difference in the recurrence of polyps according to exercise intensity was found, and their study was conducted in a short period of 3 years. Therefore, we selected colorectal cancer survivors who had well-reported physical activity and performed body composition analysis. Because the patients were colorectal cancer survivors, they were a higher risk group for adenoma recurrence than patients in the other two studies mentioned above and had a long-term follow-up period (mean, 7.83 years). These are strong points of

Published OnlineFirst June 5, 2017; DOI: 10.1158/1940-6207.CAPR-17-0065

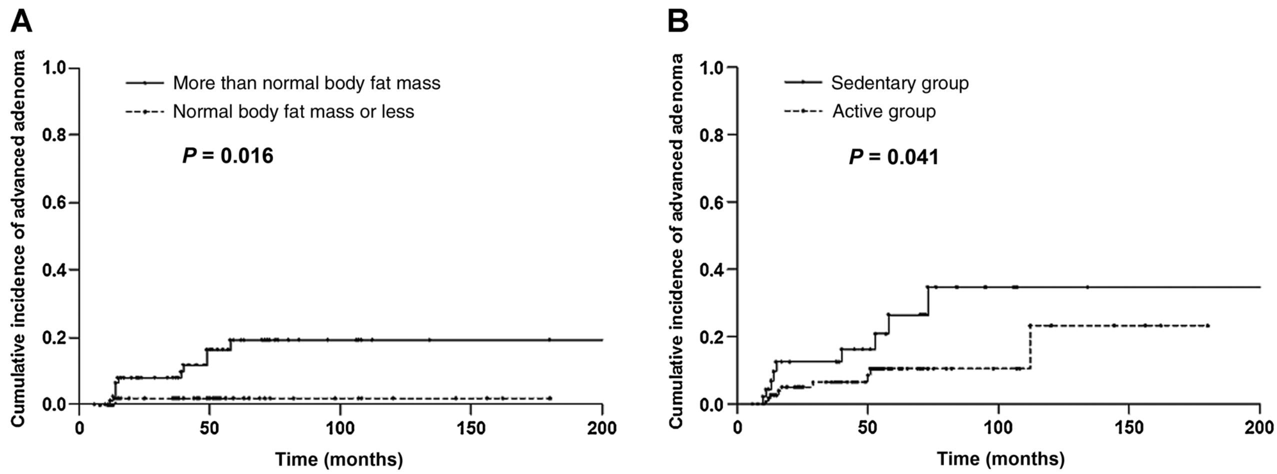

Figure 1.
Kaplan–Meier analysis (log-rank tests) to compare the cumulative rate of development of advanced adenoma between active exercise and sedentary group (**A**), and between normal or less and more than normal body fat mass group (**B**).

our study, which enable us to show a more significant difference in adenoma recurrence by intervention.

In our study, surveillance colonoscopy after treatment of colorectal cancer found an adenoma recurrence rate of 32.3% and advanced adenoma recurrence rate of 9.0%, which are similar to the results of previous studies showing an adenoma recurrence rate of 34.4% to 41.4% and advanced adenoma recurrence rate of 4.4% to 6.5% (38–40). Concerning exercise, our study showed that advanced adenoma recurred in 14.4% of the sedentary group, significantly greater than 6.4% of the active exercise group. Furthermore, as the weekly exercise hours increased, advanced adenoma development significantly decreased. Currently, the American Cancer Society Colorectal Cancer Survivorship Care Guideline and National Cancer Information Center of Korea recommend at least 150 minutes of weekly exercise and maintaining healthy body weight (41). Although the exact pathogenesis of how sedentary behavior affects tumor initiation and progression remains unclear, recent studies demonstrate that sedentary behavior dysregulates metabolism and increases adiposity, leading to hyperglycemia, hyperinsulinemia, and chronic inflammation, eventually affecting carcinogenesis (42).

Table 5. Cox proportional hazards analysis for advanced adenoma recurrence

Variables	HR (95% CI)	P^a
Age (years)	1.001 (0.958–1.046)	0.975
Male sex	1.922 (0.481–7.681)	0.355
History of alcohol	0.714 (0.167–3.060)	0.650
History of smoking	0.825 (0.198–3.447)	0.792
Family history of colorectal cancer	1.124 (0.303–4.172)	0.862
Hypertension	1.117 (0.435–2.866)	0.819
DM	1.271 (0.427–3.782)	0.667
Skeletal muscle mass (kg)	0.463 (0.059–3.661)	0.465
Body fat mass (kg)	5.315 (1.173–24.083)	0.030
Active exercise (vs. sedentary)	0.367 (0.162–0.833)	0.017
Follow-up duration (years)	0.802 (0.662–0.971)	0.024
Time to first surveillance colonoscopy (months)	0.996 (0.963–1.030)	0.818
Number of surveillance colonoscopy	1.635 (0.900–2.970)	0.106

Abbreviation: DM, diabetes mellitus.
[a]*P* value for comparing advanced adenoma group and nonadvanced adenoma group.

In terms of obesity, many studies include BMI as the measure of obesity, as well as the waist–hip circumference ratio or CT to analyze the amount of visceral fat tissue (43, 44). BMI may be an inaccurate measure of percentage body fat for an individual (45). For example, greater loss of muscle mass in women, with age, exacerbates the prevalence of false-negative BMIs (46). Abdominal visceral fat tissue in the development and progression of colorectal adenoma was a better obesity index for colorectal adenoma than BMI in both sexes (47). In our study, we used InBody 720 (Biospace) to analyze body composition and measure body fat mass and skeletal muscle mass. Bioelectrical impedance analysis by using InBody 720 uses resistance values (impedance) obtained from weak electrical currents to estimate body composition, including the intracellular and extracellular water percentages and muscle and fat mass percentages. Therefore, Inbody 720 could provide direct adiposity measurement by simultaneous measurements of muscle, bone mass, and body adiposity (46) and show to be useful as a more convenient substitute for CT when measuring visceral fat area (48, 49). Also, American Society of Bariatric Physicians recommended using both BMI and body composition analysis as criteria for intervention. This study is meaningful as the first investigation with analysis of body composition in relation to colorectal polyps. Multivariate analysis showed that increased body fat mass showed a significantly greater risk of advanced adenoma recurrence. The abovementioned observations can be explained by the possible mechanisms of visceral fat tissue in colorectal carcinogenesis. Visceral adiposity is a strong determinant of insulin resistance and subsequent hyperinsulinemia, which may be related to the growth of colorectal neoplasia in colonic mucosa (50, 51). Another possible mechanism is the association between visceral fat tissue and elevated serum levels of proinflammatory adipokines, including IL6, TNFα, and adiponectin, which may play a role in the development of colorectal adenoma (52).

Furthermore, we conducted a subgroup analysis of body fat mass and exercise amount. Our data showed that obese patients who actively exercise have a valid lower risk of advanced adenoma compared with obese patients who do not exercise. Normal or less body fat mass would bring the best results; however, for patients

Published OnlineFirst June 5, 2017; DOI: 10.1158/1940-6207.CAPR-17-0065

with increased body fat mass, exercise could be more critical to reduce the risk of advanced adenoma recurrence.

This study has the innate limitations of a retrospective cross-sectional case–control study performed in a single-tertiary university hospital. However, our study has the strong points of including a patient group with a history of colorectal cancer that is a high-risk group for colorectal neoplasia, which can show a more prominent preventive effect by intervention, and having detailed long-term follow-up surveillance data, compared with previous studies.

Another weak point of our study was that we collected physical activity and body composition data once at least 5 years after the diagnosis and treatment of colorectal cancer, which did not include those data during the total period of follow-up. In general, cancer treatment, such as surgery or chemotherapy, has a negative impact on exercise levels, and previously active individuals who fail to reinitiate exercise after cancer treatment experience the lowest quality of life 1 to 4 years later (53). In our study, we surveyed 5-year survivors of colorectal cancer and checked physical activity after a minimum period of 5 years from the initial diagnosis of cancer. Therefore, although it was a one-time measurement, because it was conducted when patients were in a relatively stable exercise pattern, it may be reflective of a stabilized amount of exercise.

In conclusion, we found that high body fat mass and low physical activity are meaningful independent risk factors of advanced adenoma recurrence in colorectal cancer survivors after treatment, suggesting the importance of exercise amount for the prevention of colorectal neoplasia.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Authors' Contributions

Conception and design: J. Park, S.J. Park, W.H. Kim, J.Y. Jeon, T.I. Kim
Development of methodology: J. Park, S.J. Park, J.S. Park, T.I. Kim
Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): J. Park, J.H. Cheon, W.H. Kim, J.S. Park, T.I. Kim
Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): J. Park, H.J. Lee, J.H. Cheon, T.I. Kim
Writing, review, and/or revision of the manuscript: J. Park, H.J. Lee, S.P. Hong, J.H. Cheon, J.Y. Jeon, T.I. Kim
Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): J.H. Kim, H.J. Lee, T.I. Kim
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Grant Support

This research was supported by a grant from the National R&D Program for Cancer Control, Ministry of Health and Welfare, Republic of Korea (1631020).

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Received March 9, 2017; revised April 23, 2017; accepted June 1, 2017; published OnlineFirst June 5, 2017.

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Published OnlineFirst June 5, 2017; DOI: 10.1158/1940-6207.CAPR-17-0065

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Cancer Prevention Research

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Cancer Prev Res Published OnlineFirst June 5, 2017.