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Original Article

Lifestyle Behaviors in Patients With Gastric Cancer: Continuous Need for Alcohol Abstinence and Muscle Strength Training Education

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ABSTRACT

Purpose: This study was performed to assess the lifestyle-related behaviors of patients with gastric cancer (GC) and to investigate the associations between the time since GC diagnosis and these behaviors.
Materials and Methods: This study included 29,478 adults (including 338 patients with GC) aged ≥ 40 years who participated in the Korea National Health and Nutrition Examination Survey 2014-2021. Multiple logistic regression analysis explored the associations between the time since GC diagnosis (patients diagnosed with GC less than 5 years ago [<5 years group] and those diagnosed with GC 5 or more than years ago [≥5 years group]) and lifestyle factors. Subgroup analyses were conducted based on age and sex.
Results: The current smoking rate was not lower in the GC group than in the healthy group, regardless of time since diagnosis. Compared to the healthy controls, monthly alcohol intake was lower in the <5 years group (odds ratio [OR], 0.450; 95% confidence interval [CI], 0.275–0.736). The ≥5 years group showed a lower rate of strength training (OR, 0.548; CI, 0.359–0.838), compared with the healthy control group. Subgroup analysis focusing on the ≥5 years group revealed a significantly lower rate of strength training, particularly in patients aged ≥65 years and male patients (OR, 0.519 and 0.553; CI, 0.302–0.890 and 0.340–0.901, respectively).
Conclusions: Clinicians should continue educating patients on lifestyle behavior modifications, particularly alcohol abstinence, even beyond 5 years after GC diagnosis. Education on strength training is especially important for patients ≥65 years or male patients.

Keywords: Gastric cancer; Smoking; Alcohol consumption; Physical activity; Community survey

INTRODUCTION

In 2020, gastric cancer (GC) was the sixth most common form of cancer worldwide [1]. Commonly recognized heterogeneous diseases, family history, *Helicobacter pylori* infection, genetic mutations, and various environmental factors contribute to the development of GC [2]. Among environmental factors, clinicians pay particular attention to lifestyle-related behaviors that can be controlled voluntarily. In particular, smoking and heavy alcohol consumption are

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

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widely known to be crucial risk factors for GC development [3,4]. In addition, physical activity (PA) has been reported to be associated with reduced risk and improved survival in several cancers, including a 19% reduction in GC risk [5]. Moreover, sarcopenia, the loss of skeletal muscle mass, is related to the prognosis and mortality of patients with GC [6].

In South Korea, where GC is one of the most common cancers, the estimated crude incidence rate is 51.2 per 100,000 people [7]. However, the 5-year overall survival rate of GC, which reached 77.0% in 2013–2019, is the highest globally owing to early endoscopic detection facilitated by the National Cancer Screening Program [8]. Increase in detection of early GC has led to a rise in function-preserving resections, including endoscopic submucosal dissection. Consequently, metachronous GC develops at an incidence of approximately 3% per year [9]. Moreover, the recurrence of GC has increased as survival rates have improved. The local recurrence rate 5 years after endoscopic resection of early GC was reported to be 11.9% [10]. Furthermore, a multicenter analysis reported that nearly one-third of the patients with GC who underwent curative gastrectomy experienced recurrence [11]. Therefore, attention should be paid to metachronous GC or its recurrence after diagnosis and treatment. Efforts should be made to avoid the risk factors associated with GC.

Therefore, it is imperative to control the environmental risk factors. However, there is still a paucity of research on changes in patients' lifestyle-related behaviors after the diagnosis of GC. Patients' attention to their health status after GC diagnosis is crucial for their prognosis and survival. This study aimed to compare ecological and lifestyle-related behaviors between patients with GC and healthy individuals and to examine the prevalence of lifestyle-related behaviors according to the time since GC diagnosis. Understanding lifestyle trends can provide both patients and clinicians with information for managing environmental risk factors for GC.

MATERIALS AND METHODS

Study design and participants

Data from the 2014–2021 Korea National Health and Nutrition Examination Survey (KNHANES) were used for analysis. Since 1998, the KNHANES, conducted by The Korea Centers for Disease Control and Prevention to evaluate family health and nutritional status in Korea, has been used for nationwide sampling through clustering, multistage stratification, and randomization techniques to ensure proportional representation based on the geographical area, sex, and age of the Korean population. Written informed consent was obtained at the time of the survey to use the data for further analysis. The raw KNHANES data are publicly available (the website address is specified in the appendix). Among the 61,758 KNHANES participants, 36,419 were aged ≥40 years. After excluding 6,941 individuals with missing data, data from the remaining 29,478 individuals were included in the analysis. This study was reviewed and approved by the Institutional Review of Board (IRB) of St. Vincent's Hospital, The Catholic University of Korea (IRB No. VC23ZASI0287). The requirement for written informed consent was waived owing to the noninterventional and retrospective nature of the study.

Assessment of GC

The classification of GC diagnosis was based on the health interview survey questionnaire, which included questions about whether a doctor had diagnosed GC, the timing of

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diagnosis, the current presence of stomach cancer, and whether GC had been treated (**Supplementary Table 1**). Among those who responded that they had been diagnosed with GC by a doctor, the age at the time of the response was compared with the time of GC diagnosis, and the respondents were classified into 2 groups: those diagnosed with GC 5 or more than years ago (≥5 years) or those diagnosed with GC less than 5 years ago (<5 years) prior to the survey.

Outcome variable

The outcome variables were lifestyle-related behaviors including smoking status, alcohol consumption status, and PA. Current smoking rate was defined as the proportion of respondents who smoked more than 5 packs (100 cigarettes) of cigarettes in their lifetime and who currently smoked cigarettes.

Drinking status was evaluated by asking participants whether they had ever consumed alcohol and how often they drank in the previous year. The monthly drinking rate was defined as the proportion of people who drank alcohol more than once a month during the past year. The heavy alcohol drinking rate was defined as the proportion of men drinking more than 7 drinks and women drinking more than 5 drinks on average per occasion, more than twice per week.

The Korean version of the Global PA Questionnaire was used to assess PA levels in different areas (work, leisure, and transportation) [12]. The proportions of aerobic, walking, and strengthening physical activities were analyzed. The rate of aerobic PA was analyzed as the proportion of responses to the following items: moderate-intensity PA for more than 2 hours and 30 minutes per week, high-intensity PA for more than 1 hours and 15 minutes, or a mixture of moderate- and high-intensity PA and spending an appropriate time at each intensity (1 minute at high-intensity PA is 2 minutes at moderate-intensity). High-intensity activity refers to vigorous PA activity involving heavy breathing or a rapid heart rate. Moderate-intensity activity denotes a moderate level of PA that results in slightly increased breathing or a slightly elevated heart rate. The rate of walking practice refers to the percentage of individuals who engaged in walking for at least 30 minutes once a day, for at least 5 days within the past week. The strength training rate indicates the percentage of individuals who practiced muscle-strengthening exercises, such as push-ups, sit-ups, weightlifting, kettlebell exercises, and pull-ups, on at least 2 days within the past week.

Covariates

Information on demographic and social factors was obtained through health interviews using a standardized questionnaire. Household income levels were categorized into quartiles, and the ratio of the lowest quartile was analyzed. Education levels were classified into 2 groups depending on whether the participant had graduated from a university.

Anthropometric measurements were obtained by well-trained staff following standard procedures across every phase of the KNHANES [12]. Participants' body weight and height were measured to the nearest 0.1 kg and 0.1 cm, respectively. Body mass index (BMI) was calculated by dividing the weight in kilograms by the height in meters squared (kg/m^2). The participants were categorized into groups based on their BMI: low weight group (BMI<18.5 kg/m^2), normal weight group (BMI=18.5–22.9 kg/m^2), overweight group (BMI=23.0–24.9 kg/m^2), and obese group (BMI≥25.0 kg/m^2). Blood samples were collected in the morning after fasting for at least 8 hours and analyzed in a central certified laboratory. A diagnosis of diabetes was based on fasting plasma glucose level ≥126 mg/dL, current use of antidiabetic

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medication, or HbA1c ≥6.5%. Hypertension was defined as systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg, or use of antihypertensive medications. Hypercholesterolemia was defined as a total cholesterol level ≥240 mg/dL, a diagnosis of hypercholesterolemia, or the use of anti-cholesterol medications.

Statistical analysis

Data were analyzed using SAS version 9.4 (SAS Institute, Cary, NC, USA), considering sampling weights to provide nationally representative estimates. Continuous variables were analyzed using analysis of variance and are presented as mean ± standard error (SE), while categorical variables were compared using the χ^2 test and are presented as percentages (SE). The association between GC and outcome variables was assessed using multivariate logistic regression analysis with 3 models for adjustment. Model 1 represented a non-adjusted analysis, while model 2 included age and sex as adjusting factors, and model 3 incorporated age, sex, BMI, education, household income, and comorbidities (diabetes, hypertension, and hypercholesterolemia) as adjusting factors. All tests were 2-sided, unless otherwise indicated. Subgroup analyses were performed using model 3. In all analyses, statistical significance was set at P<0.05.

RESULTS

Baseline characteristics

This study included 338 patients with GC, consisting of 107 patients in <5 years group and 231 patients in ≥5 years group (**Fig. 1**). **Table 1** presents the baseline patient characteristics. The mean age was significantly higher in the ≥5 years group with an average of 66.92±0.85 years (P<0.001). Sex distribution showed significant differences, with 48.33% males in the healthy control group, 64.29% in the <5 years group, and 59.3% in the ≥5 years group (P<0.001). The GC group had higher rates of normal weight and underweight and a lower rate of obesity than those of the healthy control group (P<0.001). With regard to social characteristics, the rate of low household income was significantly higher, and the rate of university or higher education was significantly lower in the ≥5 years group. The rates of diabetes mellitus and hypertension were not significantly different among the 3 groups. However, the rate of

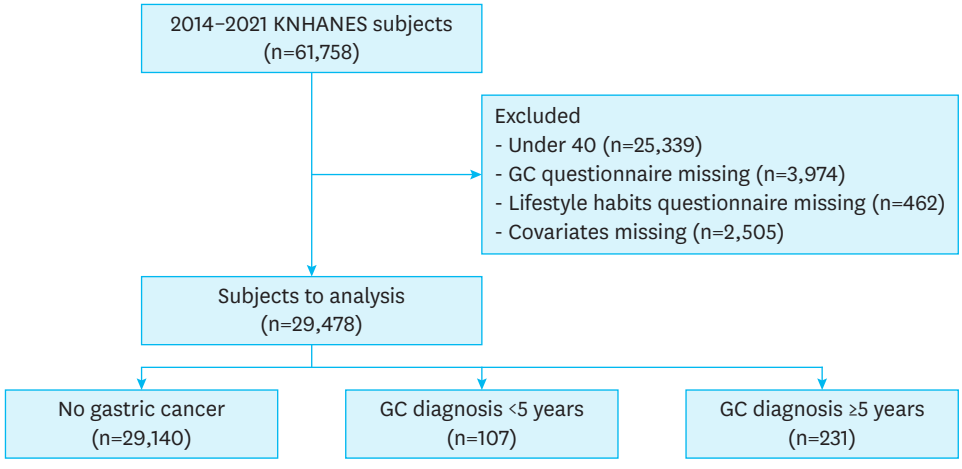

Fig. 1. Flowchart.
KNHANES = Korea National Health and Nutrition Examination Survey; GC = gastric cancer.

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Table 1. General characteristics of study populations

Variables	No GC diagnosis (n=29,140)	GC diagnosis <5 yr (n=107)	GC diagnosis ≥5 yr (n=231)	P-value
Age (yr)	56.49±0.11	64.6±1.21	66.92±0.85	<0.001
≥65 yr	23.84 (0.38)	45.23 (5.51)	59.5 (3.85)	<0.001
Sex (male)	48.33 (0.27)	64.29 (5.58)	59.3 (3.75)	<0.001
Household income	17.25 (0.4)	24.56 (4.82)	35.12 (3.54)	<0.001
Education	33.24 (0.59)	26.25 (5.04)	21.15 (3.36)	0.003
BMI (kg/m^2)	24.22±0.02	21.94±0.27	22.28±0.25	<0.001
Obesity				<0.001
Underweight	2.34 (0.11)	6.42 (2.66)	7.84 (1.76)	
Normal	35.16 (0.34)	55.3 (5.55)	58.83 (3.75)	
Overweight	25.17 (0.31)	29.28 (5.02)	15.29 (2.63)	
Obesity	37.33 (0.35)	9.00 (2.82)	18.04 (3.00)	
Comorbidity				
DM	16.97 (0.28)	25.3 (5.48)	20.55 (2.84)	0.077
Hypertension	37.3 (0.39)	33.79 (5.06)	40.8 (3.78)	0.504
Hypercholesterolemia	27.76 (0.32)	21.89 (4.74)	16.82 (2.74)	0.003
Sm_present	18.57 (0.31)	16.05 (5)	12.49 (2.71)	0.182
Alc_month	52.86 (0.36)	33.12 (5.39)	47.24 (3.84)	<0.001
Alc_high	12.33 (0.25)	12.85 (4.46)	9.79 (2.54)	0.678
Pa_aerobic	42.81 (0.39)	38.23 (5.55)	38.33 (3.96)	0.387
Pa_walk	38.38 (0.38)	45.69 (5.54)	48.43 (3.84)	0.011
Pa_strength	20.86 (0.29)	30.25 (5.46)	15.09 (2.66)	0.024

Variables are presented as mean±standard error or percentage (standard error).
GC = gastric cancer; BMI = body mass index; DM = diabetes mellitus; Sm_present = current smoking rate; Alc_month = monthly alcohol consumption rate; Alc_high = high-risk alcohol consumption rate; Pa_aerobic = aerobic physical activity practice rate; Pa_walk = walking practice rate; Pa_strength = strength training rate.

hypercholesterolemia was significantly lower in the GC group, especially in the ≥5 years group, compared to the healthy controls.

Smoking, alcohol consumption, and PA

The current smoking rate was 18.57% in the healthy control group, 16.05% in the <5 years group, and 12.49% in the ≥5 years group, although these differences were not significant (P=0.182). Monthly alcohol consumption was significantly different among the 3 groups. The monthly alcohol consumption rate was 52.86% in the healthy control group, 33.12% in the <5 years group, and 47.24% in the ≥5 years group. The rate of high-risk alcohol consumption was 12.33% in the healthy control group, 12.85% in the <5 years group, and 9.79% in the ≥5 years group, but these differences were not significant (P=0.678). The rate of aerobic PA did not differ significantly among the 3 groups (P=0.387). However, both walking practice and strength training rates exhibited significant differences among the 3 groups (P=0.011, 0.024, respectively) (**Table 1**).

Table 2 and **Fig. 2** show the association between GC diagnosis and smoking status, alcohol consumption, and physical status. The current smoking rate did not differ significantly between the healthy control group and both the <5 years group and ≥5 years group. In the <5 years group, the monthly alcohol consumption rate was significantly lower than that in the healthy control group (odds ratio [OR], 0.450; 95% confidence interval [CI], 0.275–0.736). In terms of PA, the <5 years group did not show significant differences compared with the healthy control group. Conversely, in the ≥5 years group, there was no significant difference in the monthly alcohol consumption rate compared to that of the healthy control group. Additionally, in terms of PA, the ≥5 years group exhibited a significantly higher walking practice rate but a significantly lower strength training rate compared to those of the healthy control group (OR, 1.406; 95% CI, 1.090–1.814; OR, 0.548; 95% CI, 0.359–0.838, respectively).

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Table 2. Multivariate analysis according to the gastric cancer diagnosis

Variables	Gastric cancer	% (SE)	Model 1*		Model 2†		Model 3‡	
			OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value
Sm_present	No	18.57 (0.31)	1 (Ref.)	0.076	1 (Ref.)	0.220	1 (Ref.)	0.074
	Yes	13.62 (2.43)	0.692 (0.460–1.040)		0.763 (0.496–1.176)		0.671 (0.433–1.039)	
	No	18.57 (0.31)	1 (Ref.)	0.152	1 (Ref.)	0.430	1 (Ref.)	0.198
	<5 yr	16.05 (5.00)	0.839 (0.404–1.739)		0.826 (0.379–1.802)		0.701 (0.337–1.457)	
	≥5 yr	12.49 (2.71)	0.627 (0.385–1.021)		0.731 (0.440–1.214)		0.655 (0.381–1.124)	
Alc_month	No	52.86 (0.36)	1 (Ref.)	0.001	1 (Ref.)	0.061	1 (Ref.)	0.144
	Yes	42.75 (3.07)	0.667 (0.521–0.854)		0.785 (0.609–1.011)		0.829 (0.645–1.066)	
	No	52.86 (0.36)	1 (Ref.)	0.001	1 (Ref.)	0.005	1 (Ref.)	0.006
	<5 yr	33.12 (5.39)	0.442 (0.274–0.713)		0.429 (0.258–0.713)		**0.450 (0.275–0.736)**	
	≥5 yr	47.24 (3.84)	0.799 (0.591–1.080)		1.036 (0.768–1.398)		1.103 (0.817–1.489)	
Alc_high	No	12.33 (0.25)	1 (Ref.)	0.513	1 (Ref.)	0.789	1 (Ref.)	0.199
	Yes	10.76 (2.24)	0.857 (0.541–1.359)		1.064 (0.673–1.684)		1.337 (0.858–2.082)	
	No	12.33 (0.25)	1 (Ref.)	0.664	1 (Ref.)	0.933	1 (Ref.)	0.403
	<5 yr	12.85 (4.46)	1.049 (0.478–2.298)		1.165 (0.518–2.621)		1.560 (0.717–3.394)	
	≥5 yr	9.79 (2.54)	0.772 (0.438–1.360)		1.012 (0.581–1.761)		1.227 (0.722–2.084)	
Pa_aerobic	No	42.81 (0.39)	1 (Ref.)	0.171	1 (Ref.)	0.919	1 (Ref.)	0.865
	Yes	38.30 (3.21)	0.829 (0.635–1.084)		1.014 (0.779–1.319)		0.977 (0.748–1.276)	
	No	42.81 (0.39)	1 (Ref.)	0.391	1 (Ref.)	0.984	1 (Ref.)	0.958
	<5 yr	38.23 (5.55)	0.827 (0.521–1.313)		0.985 (0.629–1.542)		0.934 (0.592–1.475)	
	≥5 yr	38.33 (3.96)	0.831 (0.598–1.154)		1.028 (0.745–1.419)		0.998 (0.721–1.381)	
Pa_walk	No	38.38 (0.38)	1 (Ref.)	0.003	1 (Ref.)	0.004	1 (Ref.)	0.009
	Yes	47.56 (3.19)	1.456 (1.132–1.873)		1.449 (1.126–1.865)		**1.406 (1.090–1.814)**	
	No	38.38 (0.38)	1 (Ref.)	0.013	1 (Ref.)	0.015	1 (Ref.)	0.030
	<5 yr	45.69 (5.54)	1.351 (0.871–2.095)		1.363 (0.879–2.114)		1.307 (0.842–2.029)	
	≥5 yr	48.43 (3.84)	1.508 (1.114–2.041)		1.491 (1.100–2.021)		1.455 (1.069–1.982)	
Pa_strength	No	20.86 (0.29)	1 (Ref.)	0.720	1 (Ref.)	0.367	1 (Ref.)	0.101
	Yes	19.90 (2.60)	0.944 (0.685–1.301)		0.861 (0.623–1.189)		0.757 (0.542–1.056)	
	No	20.86 (0.29)	1 (Ref.)	0.025	1 (Ref.)	0.024	1 (Ref.)	0.014
	<5 yr	30.25 (5.46)	1.647 (0.991–2.739)		1.465 (0.888–2.419)		1.275 (0.753–2.160)	
	≥5 yr	15.09 (2.66)	0.675 (0.449–1.015)		0.622 (0.411–0.940)		**0.548 (0.359–0.838)**	

Bold are presented as significant results.
SE = standard error; OR = odds ratio; CI = confidence interval; Sm_present = current smoking rate; Alc_month = monthly alcohol consumption rate; Alc_high = high-risk alcohol consumption rate; Pa_aerobic = aerobic physical activity practice rate; Pa_walk = walking practice rate; Pa_strength = strength training rate.
*Model 1: multivariate logistic regression analysis without adjustments; †Model 2: multivariate logistic regression analysis adjusted for age and sex; ‡Model 3: multivariate logistic regression analysis adjusted for age, sex, body mass index, education, household income, and comorbidities.

Subgroup analysis

Subgroup analysis according to age (<65 years vs. ≥65 years) and sex was conducted. The rate of high-risk alcohol consumption was significantly higher in the <65 years group than in the healthy control group (OR, 1.953; 95% CI, 1.029–3.707). While the <65 years group showed no significant difference in the rate of strength training compared to that in healthy controls, the ≥65 years group exhibited a significantly lower rate of strength training (OR, 0.519; 95% CI, 0.302–0.890). Subgroup analysis based on sex in the ≥5 years group revealed that, in comparison with that of the healthy control group, the male subgroup significantly demonstrated a lower rate of strength training, whereas no significant difference was observed among females (OR, 0.553; 95% CI, 0.340–0.901) (**Supplementary Tables 2** and **3**).

In the subgroup analysis for the <5 years group, individuals aged ≥65 years exhibited a significantly lower current smoking rate compared to that of the healthy control group (OR, 0.271; 95% CI, 0.091–0.813). However, among females, the current smoking rate was significantly higher than that in the healthy control group (OR, 4.895; 95% CI, 1.431–16.743) (**Supplementary Tables 2** and **3**).

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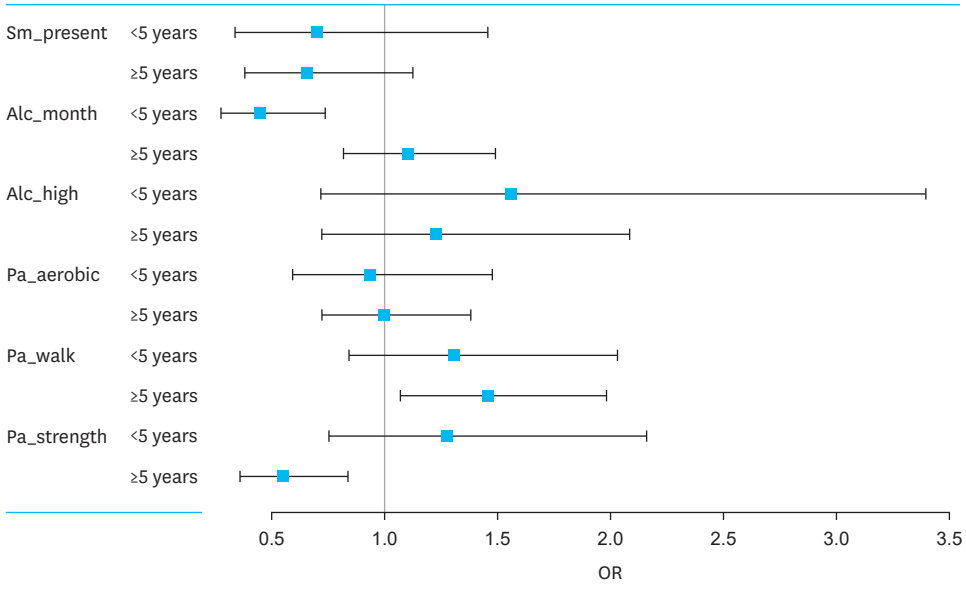

Fig. 2. OR plot for the association of gastric cancer diagnosis with lifestyle variables (this plot is based on the results of model 3, adjusted for age, sex, body mass index, education, household income, and comorbidities). Sm_present = current smoking rate; Alc_month = monthly alcohol consumption; Alc_high = high-risk alcohol consumption rate; Pa_aerobic = aerobic physical activity rate; Pa_walk = walking exercise rate; Pa_strength = strength training rate; OR = odds ratio.

DISCUSSION

Maintaining a healthy lifestyle is crucial for improving the quality of life and prognosis of cancer survivors [13]. While there are evidence-based guidelines for the diagnosis and treatment of GC [14], there has been a paucity of research on how lifestyle-related behaviors are sustained after the diagnosis of GC. In this study, differences in lifestyle-related behaviors were examined based on the diagnosis and time since GC diagnosis. Within the first 5 years of GC diagnosis, lifestyle-related behaviors appeared to be relatively well managed. The current smoking rate was lower in patients aged ≥65 years compared to that of the healthy control group, and the monthly alcohol consumption rate was lower, regardless of age. However, a different pattern of lifestyle-related behaviors was identified 5 years after GC diagnosis. In the <65 years age group, the rate of high-risk alcohol consumption was elevated among patients with GC than among healthy controls. Regarding PA, the rate of walking as an exercise was similar to or higher in patients with GC than in healthy controls. However, the rate of strength training, especially in males or individuals aged ≥65 years, was lower than that in the healthy control group. These findings underscore the importance of continuous lifestyle management for patients with GC, particularly for 5 years post-diagnosis.

Smoking is a significant risk factor for GC because tobacco contains over 7,000 toxic chemicals, including carcinogens. Nicotine, present in tobacco, induces the expression of cyclooxygenase-2, prostaglandin E2, vascular endothelial growth factor, and extracellular signal-regulated protein kinase, which can induce GC cell proliferation and tumor angiogenesis [15]. In addition, nicotine decreases anti-proliferative gene expression by inducing microRNA pathways [16]. Individuals with a history of smoking have a 1.5–2.5 times increased risk of developing GC compared with that of nonsmokers [17]. Moreover, moderate and heavy smokers show a dose-dependent pattern of elevated GC risk compared with

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individuals who have never smoked [18]. A previous nationwide study in Korea demonstrated that consistent male smokers after GC diagnosis have an increased risk of all-cause and cancer-related mortality [19]. However, in the present study, no decrease in the current smoking rate was observed in the GC group compared to that in the healthy control group. Therefore, continuous education regarding smoking cessation is essential for patients who continue smoking after being diagnosed with GC.

Alcohol, categorized as a group 1 carcinogen, is associated with risks of cancer of the stomach, liver, gallbladder, pancreas, oral cavity, and lungs [20,21]. Although the mechanism underlying the association between alcohol consumption and increased cancer risk is not yet clear, the nitrosamine nitrosodimethylamine in alcohol is a carcinogen that can contribute to GC carcinogenesis [22]. Alcohol is highly addictive and stimulates the release of the neurotransmitter dopamine into the brain [23]. In this study, the monthly alcohol consumption rate was significantly lower in the <5 years group than in healthy controls. However, the ≥5 years group showed no difference in monthly alcohol consumption rate compared to the healthy control group, and the rate of high-risk alcohol consumption was elevated in those aged <65 years compared to that in the healthy control group. These results may have been attributable not only to the addictive nature of alcohol but also to the possibility that adequate follow-up strategies are not well established for ≥5 years post-diagnosis. In a recent survey conducted in Korea, 60% of 71 representative clinicians stated that they did not perform follow-ups for stage I patients with GC 5 years after the initial diagnosis [14]. The results of this study emphasize the necessity for continuous education regarding alcohol abstinence for patients with GC, even 5 years after diagnosis.

Sarcopenia is a critical prognostic factor for patients with GC [24]. It becomes particularly crucial for patients with GC who have undergone gastrectomy, as the surgery reduces stomach volume, decreases oral intake, and leads to weight loss [25]. Therefore, preventing sarcopenia through muscle strength training is imperative in these patients. Strength training is associated with a reduction in sarcopenia in patients with cancer by promoting muscle hypertrophy and mitigating hypotonia and muscle weakness [26]. In this study, the walking exercise rate was higher in the GC group than in the healthy control group. However, the muscle strength training rate was significantly lower in the ≥5 years group than in the healthy control group. Clinicians often provide only vague recommendations for physical exercise, without specifying walking exercises or muscle strength training. This may explain why the GC group had a higher rate of walking exercise but a lower rate of muscle strength training than those of the healthy control group. Currently, there are no established strategies for PA in patients with GC, highlighting the need for further research on this issue.

This study has several limitations. First, this was a cross-sectional study and therefore could not explain the causal relations of the variables. Lifestyle-related behaviors were assessed only once, precluding the investigation of changes in lifestyle patterns over time. Furthermore, this study could not provide insights into whether well-regulated lifestyle-related behaviors are correlated with differences in the progression pattern or survival of patients with GC. Second, the lifestyle data used in this study were dependent only on the respondents' memories, which may have resulted in recall bias. Third, information on the pathological characteristics, treatment details, and recurrence status of GC was lacking. Patients undergoing gastric resection or chemotherapy may encounter restrictions in PA, especially muscle strength training, owing to factors such as dietary restrictions; this was a confounding factor that may have affected the interpretation of the results. Finally, the

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small sample size in the subgroup analysis may have reduced statistical power. This may have attributed to the significantly higher current smoking rate in females in the <5 years group compared to those in the healthy control group.

Despite these limitations, the present study has several strengths. First, this study utilized high-quality data from the KNHANES. Annually, KNHANES randomly selects 4,800 households (as of the 2019–2021 period) from 192 survey districts, aiming to represent the entire population of South Korea. Consequently, the results of this study can be interpreted as representing the entire population of South Korea [12]. Second, this was the first study to examine trends in lifestyle behaviors after GC diagnosis. This study highlights the inadequate management of lifestyle behaviors, especially alcohol consumption and muscle strength training, beyond 5 years of GC diagnosis, emphasizing continuous education and support for patients with GC.

In conclusion, understanding lifestyle trends can help both patients and clinicians manage the environmental risk factors for GC recurrence. In this study, lifestyle behaviors among patients with GC are well-regulated within the first 5 years after diagnosis. However, beyond this period, alcohol consumption and muscle strength training tends to be poorly regulated. Hence, clinicians should continue to provide education on lifestyle behavior modification even 5 years after GC diagnosis. Education on alcohol abstinence is particularly crucial for patients aged <65 years. Additionally, education on muscle strength training, which is beneficial for preventing sarcopenia, is particularly necessary for patients aged ≥65 years or male patients. Further research on the effects of lifestyle modifications is necessary to provide decisive evidence for patients to change their lifestyle behaviors.

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Raw data from the KNHANES can be accessed at the following website: https://knhanes.kdca.go.kr/knhanes/sub03/sub03_02_05.do

SUPPLEMENTARY MATERIALS

Supplementary Table 1
Survey items regarding gastric cancer diagnosis

Supplementary Table 2
Subgroup analysis according to the age

Supplementary Table 3
Subgroup analysis according to the sex

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