

# Lifestyle intervention for gastroesophageal reflux disease: a national multicenter survey of lifestyle factor effects on gastroesophageal reflux disease in China

Ling-Zhi Yuan , Ping Yi, Gang-Shi Wang, Shi-Yun Tan, Guang-Ming Huang, Ling-Zhi Qi, Yan Jia and Fen Wang

## Abstract

**Background:** Poor habits can worsen gastroesophageal reflux disease (GERD) and reduce treatment efficacy. Few large-scale studies have examined lifestyle influences, particularly eating habits, on GERD in China, and research related to eating quickly, hyperphagia, and eating hot foods is quite limited. The aim of this study was to evaluate the relationship between GERD pathogenesis and lifestyle factors to produce useful information for the development of a clinical reference guide through a national multicenter survey in China. **Methods:** Symptom and lifestyle/habit questionnaires included 19 items were designed. The questionnaire results were subjected to correlation analysis relative to GERD symptom onset. A standard proton pump inhibitor (PPI) was advised to correct patients with unhealthy lifestyle habits.

**Results:** A total of 1518 subjects (832 GERD, 686 non-GERD) enrolled from six Chinese hospitals completed symptom and lifestyle/habit questionnaires. The top lifestyle factors related to GERD were fast eating, eating beyond fullness, and preference for spicy food. Univariate analysis showed that 21 factors, including male gender, a supra-normal body mass index (BMI), smoking, drinking alcohol, fast eating, eating beyond fullness, eating very hot foods, and drinking soup, among others, were associated with GERD ( $p < 0.05$ ). Logistic multivariate regression analysis revealed the following risk factors for GERD [with odds ratios (ORs)]: fast eating (4.058), eating beyond fullness (2.849), wearing girdles or corsets (2.187), eating very hot foods (1.811), high BMI (1.805), lying down soon after eating (1.544), and smoking (1.521). Adjuvant lifestyle interventions improved outcomes over medication alone ( $z = -8.578, p < 0.001$  Mann-Whitney rank sum test).

**Conclusions:** Lifestyle interventions can improve medication efficacy in GERD patients. Numerous habits, including fast eating, eating beyond fullness, and eating very hot foods, were associated with GERD pathogenesis. The present results may be useful as a reference for preventive education and treatment.

**Keywords:** dietary habits, gastroesophageal reflux disease (GERD), hyperphagia, life style, therapeutics

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## Introduction

Gastroesophageal reflux disease (GERD) is characterized by abnormal gastric reflux into the

esophagus at least once a week leading to heartburn and acid regurgitation.<sup>1</sup> It is a common disease globally, with increasing prevalence, and,

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consequently, greater burden on healthcare systems.<sup>2,3</sup> The prevalence rates of GERD in Western countries, where it is most prevalent, have been reported to be 10–20%.<sup>4</sup> Meanwhile, recent modernization of living standards, and the accompanying lifestyle changes and acceleration of the pace of life, have led to an increasing prevalence of symptomatic GERD in China, which reached 3.8% in 2016.<sup>5</sup> Because of repeated treatment and prolonged healing, GERD is associated with reduced health-related quality of life,<sup>6</sup> substantial costs for patients,<sup>7</sup> and increased risk of esophageal adenocarcinoma.<sup>8</sup>

GERD has been reported to be alleviated, or even cured, with a combination of lifestyle interventions and medication.<sup>9</sup> Moreover, poor lifestyle habits can worsen GERD and reduce treatment efficacy.<sup>10</sup> A consensus of GERD treatment strategy has yet to be established due to the lack of a unified view of GERD-promoting behavior. For example, opposing effects of coffee or caffeine on GERD have been reported,<sup>11,12</sup> questions remain about the potential relationship between esophageal acid exposure and meal times,<sup>13,14</sup> as well as about whether GERD symptoms are related to body mass index (BMI).<sup>15,16</sup> Because it is difficult for patients who lack awareness of what constitutes a high-risk lifestyle to correct unhealthy habits after the emergence of red-flag symptoms before irreversible damage has been done, such patients tend to have poor drug treatment outcomes.

Lifestyle changes for GERD recommended by the American College of Gastroenterology, in 2013, and the Chinese Medical Association Digestive Diseases Branch, in 2014, include weight loss, head-of-bed elevation, cessation of smoking and frequent alcohol use, avoidance of meals 2–3 h before bedtime, and reduced intake of coffee, chocolate, spices, acidic foods, and high-fat foods. The lifestyle interventions mentioned in the guide, however, are quite limited.

GERD may progress from reflux esophagitis to Barrett's esophagus (precancerous esophageal adenocarcinoma lesions), and, ultimately, to esophageal adenocarcinoma, a gravely serious outcome of GERD comorbidity with esophageal injury syndrome. In our prior investigation of 103 patients with esophageal cancer, we found that many patients with esophageal cancer had habits such as eating quickly, eating until very full, and

consuming very hot foods, that are not addressed in GERD lifestyle intervention therapy guidance.

Few large-scale studies have examined lifestyle influences on GERD in China, and research related to eating quickly, eating beyond fullness, and eating hot foods, particularly, is quite limited. In the present study, we sought to examine which of these habits may be responsible for GERD pathogenesis. Toward this aim, we analyzed lifestyle questionnaires from GERD patients from six hospitals in China relative to GERD onset and aggravation.

## Materials and methods

### Participants

From August 2015 to August 2017, patients with upper gastrointestinal symptoms attending digestive clinics at six hospitals (the Third Xiangya Hospital of Central South University, the General Hospital of Chinese People's Liberation Army, the People's Hospital of Wuhan University, the Second Affiliated Hospital of Nanjing Medical University, the People's Hospital of Jilin Province, and Army General Hospital) were invited to complete a questionnaire. This study was approved by the Third Xiangya Hospital Ethics Committee of Central South University (approval number 2018-S384). Written informed consent forms were obtained from all participants before questionnaire disbursement. All of our GERD group patients' symptoms were treated with a standard proton pump inhibitor (PPI). All of these patients were advised to correct bad lifestyle habits.

*Inclusion criteria.* The GERD case group inclusion criteria could be met in two ways: presentation with typical clinical GERD manifestations (i.e. nausea, acid regurgitation, and heartburn), a total score  $\geq 12$  on the reflux diagnostic questionnaire used for initial GERD diagnosis, and a positive PPI test; or endoscopic/imaging demonstration of esophageal disease, an erosive esophagus inflammation diagnosis, or a Barrett's esophagus diagnosis. Patients meeting either one of these two criteria sets were eligible for enrollment.

The control group inclusion criteria sets were as follows: an absence of GERD-typical symptoms (nausea, acid reflux, heartburn, and substernal pain), a total score  $< 12$  on the reflux diagnostic questionnaire used for initial GERD diagnosis;

and endoscopic- or imaging-based ruling out of the a forementioned esophageal disease manifestations. To be selected as controls, subjects were required to meet both criteria sets.

*Exclusion criteria.* The exclusion criteria for the GERD case group were gastrointestinal related organic lesions (including esophageal hiatal hernia); surgery within 1 year before being diagnosed with GERD; diagnosis with diffuse esophageal fistula or achalasia, and suspected malignancy; inability to complete 2 weeks of treatment and follow up; major mental illness or communication disorder; and serious comorbidity. The exclusion criteria for the control group were diagnosis with a disease or major mental illness.

### Study design

Outpatients completed questionnaires independently. We conducted diagnostic PPI treatments in all enrolled patients. GERD patients were selected according to clinical symptom score, endoscopy findings, and PPI test results. The relationships between GERD incidence and habits were analyzed.

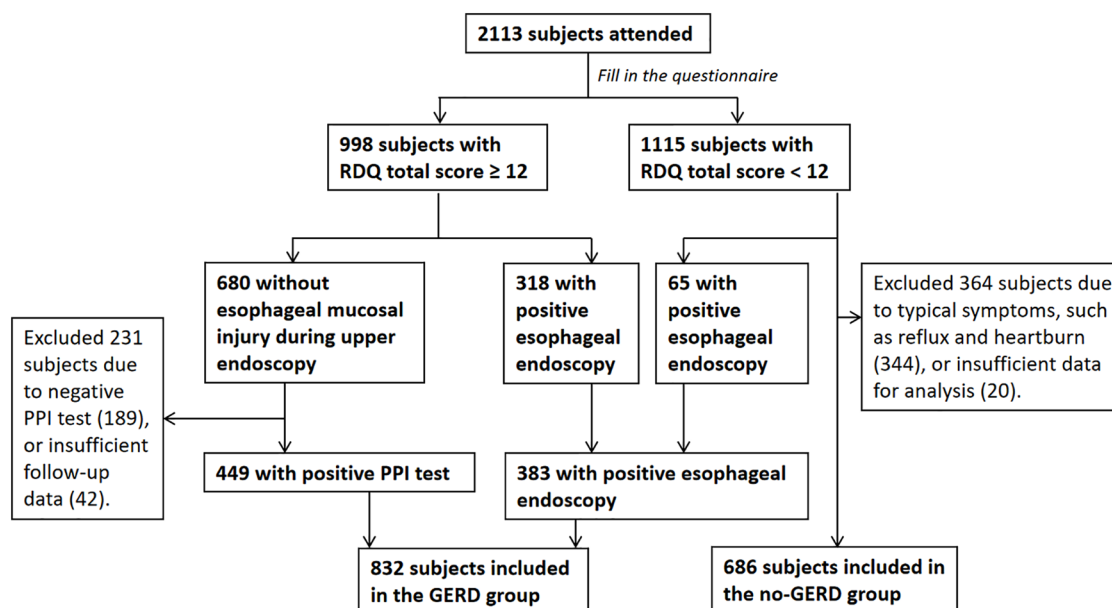
### Questionnaires

The survey included four Simplified Chinese Questionnaires: a demographic questionnaire (name, gender, age, occupation, height, weight, contact information); a reflux disease questionnaire (RDQ) to assess typical GERD symptoms; a query for gastroscopy/imaging findings; and a lifestyle questionnaire.

*RDQ structure and scoring.* The RDQ was used to collect detailed information about GERD symptoms, including reflux, acid regurgitation, heartburn, and substernal pain in the past 4 weeks,<sup>1</sup> as well as information regarding symptom frequency and severity, classified according to intrinsic scoring criteria.<sup>17</sup> Prior studies have demonstrated the utility of the RDQ in GERD diagnosis.<sup>17,18</sup> In the RDQ, frequency of the symptoms of nausea, acid regurgitation, heartburn, and substernal pain were graded as: never = 0 points; <1 day/week = 1 point; 1 day/week = 2 points; 2–3 day/week = 3 points; 4–5 day/week = 4 points, and 6–7 day/week = 5 points. Severity of these symptom categories were graded as follows: not present = 0 points; not obvious/subtle = 1 point; mild (degree of symptoms intermediate between 1 point and 3 points) = 2

points; severe enough to sometimes affect daily life and requires medication occasionally = 3 points; moderately severe (degree of symptoms intermediate between 3 points and 5 points); very severe, affecting daily life markedly and requiring medication regularly = 5 points. RDQ frequency and severity subscores each ranged from 0 (none of the symptoms experienced) to 20 (maximal frequency or severity of all four categories), with a maximal combined score of 40 (sum of frequency and severity scores) and higher scores indicating a more severe presentation. The common RDQ screening GERD cut-off of 12 points was adopted.

*Assessment of lifestyle and eating habits.* The lifestyle questionnaire included 19 items assessing the following habits: smoking, alcohol drinking, fast eating, eating beyond fullness, lying down soon after eating, eating shortly before bedtime, difficulty with defecation, sleep difficulties, feeling stress continually, wearing girdles or corsets, and consumption of very hot substances, strong teas, and coffee, as well as preferences for drinking soup, spicy foods, high-fat foods, acidic foods, sweets, and hard/solid foods. A regular smoker was defined as a person who smokes  $\geq 1$  cigarette/day, for 6 months continuously or cumulatively, in accordance with World Health Organization (WHO) standards. A drinker was defined as a person with a daily alcohol consumption level of >25 g for men or >15 g for women, for 6 months continuously or cumulatively, in accordance with the recommendations of the Chinese Ministry of Health. Dietary habits were assessed with 11 items (defining clarifications in parentheses): fast eating (<10 min per meal and chewing <10 times per bite); eating beyond fullness (continuing to eat beyond a sensation of fullness until unable to eat any more); eating too-hot foods (>60°C); preference for drinking soup; preference for spicy foods; preference for high-fat food (e.g. chocolates, fried foods, animal offal); preference for acidic foods (e.g. citrus fruits and acidic drinks); preference for sweets (e.g. cream, cake, chocolate); preference for hard foods (e.g. walnuts, peanuts); preference for strong teas (>3 g of tea); and preference for coffee drinking. Lifestyle habits were assessed with the following six items: lying down soon after eating (<30 min); eating just before bedtime (within 2 h); difficulty defecating (inability or time consuming); sleep difficulties (insufficient sleep sleepwalking, night terrors, nightmares, etc.); anxiety (e.g. irritability, panic); and wearing girdles or corsets. Preference was



**Figure 1.** Study recruitment flowchart.

Of 2113 potential participants, 832 met the GERD case group criteria. Among them, 449 had an RDQ score  $\geq 12$  and a positive PPI test, and 383 had a positive esophageal endoscopy. The non-GERD group included 686 patients with RDQ scores  $< 12$  and negative esophageal endoscopy. Patients with data analysis difficulties due to data loss or incomplete data were excluded. GERD, gastroesophageal reflux disease; PPI, proton pump inhibitor; RDQ, reflux disease questionnaire.

defined as engaging in the habit  $> 3$  day/week, continuously or cumulatively for 6 months.

#### *PPI test*

Participants received a standard diagnostic oral PPI test in which they took esomeprazole (20 mg) or lansoprazole (30 mg) enteric-coated tablets twice per day for 2 weeks. No other drugs were taken during the treatment. Subsequently, patients were followed up in an outpatient clinic or telephone appointment, and completed the RDQ again. The PPI test was considered positive (supporting a GERD diagnosis) if the symptom score was reduced by  $> 80\%$  versus pretreatment.

#### *Follow up and efficacy*

We performed regular telephone follow up (half-month, 1 month, 3 months, and 6 months after commencing treatment). At each follow up, the patients recompleted the RDQ and were asked about whether they had made favorable lifestyle changes. The half-month follow-up results were used to judge PPI test results. Patients who followed all recommended habit changes formed the observation subgroup; those who followed some or none of the recommendations formed the lifestyle control subgroup. We compared pretreatment

versus 6-month follow-up RDQ scores. If the total score decreased by  $> 80\%$ ,  $50\text{--}80\%$ , or  $< 50\%$ , the intervention was considered substantially effective, moderately effective, or invalid, respectively. The total effective rate was the sum of the effective and moderately effective rates.

#### *Statistical analysis*

Quantitative data were compared across groups with *t*-tests. The Wald test was used for univariate analysis. Significant factors from the univariate analysis were included in a multivariate logistic regression analysis (method: Enter). Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated by logistic regression. Our sample was derived from the grade/frequency table data of two-independent samples, so the relationship between outcomes and habit revision was analyzed by variance and the Mann-Whitney rank sum test.  $p < 0.05$  was considered significant. SPSS 20.0 were used for the analysis.

## **Results**

#### *Characteristics of study subjects*

Enrollment and group designation are summarized in Figure 1. The size, gender ratio, and age

characteristics of the GERD case group and non-GERD control group are reported in Table 1. The ages of patients in both groups have a normal distribution.

#### *GERD-correlated factors*

The composition ratio analysis results for GERD-correlated factors are reported in Table 2. Eating too fast and eating beyond fullness were habits

**Table 1.** Baseline demographic characteristics of GERD and non-GERD groups.

Baseline characteristics	GERD (n = 832)	Non-GERD (n = 686)
Age, years		
Mean (standard deviation)	48.51 (13.22)	47.45 (14.86)
Range	17–86	15–84
Gender, n (%)		
Male	455 (54.69)	302 (44.02)
Female	377 (45.31)	384 (55.98)
GERD, gastroesophageal reflux disease.		

**Table 2.** Number and composition ratio of lifestyle habit factors by group.

Lifestyle factors	GERD		Non-GERD	
	n	Composition ratio, %	n	Composition ratio, %
Fast eating	663	79.7	244	35.6
Eating beyond fullness	568	68.3	190	27.7
Preference for spicy foods	509	61.2	28	42.0
Preference for soup	437	52.5	312	45.5
Preference for sweets	435	52.3	270	39.4
Chronic stress	431	51.8	280	40.8
Preference for high-fat foods	418	50.2	170	24.8
Eating too-hot food	371	44.6	148	21.6
Sleep difficulty	334	40.1	218	31.8
Lying down soon after eating	316	38.0	144	21.0
Preference for hard foods	294	35.3	112	16.3
Smoking	289	34.7	122	17.8
Preferring spicy food	287	34.5	124	18.1
Drinking alcohol	235	28.2	98	14.3
Drinking strong tea	232	27.9	82	12.0
Eating just before bedtime	209	25.1	132	19.2
Difficulty with defecation	170	20.4	92	13.4
Wearing girdles or corsets	156	18.8	40	5.8
Drinking coffee	113	13.6	36	5.2
GERD, gastroesophageal reflux disease.				



**Table 3.** Univariate analysis of GERD-related demographic risk factors.

Factor	Number in group		$\chi^2$	<i>p</i>
	GERD	Non-GERD		
Gender			17.11	<b>&lt;0.001</b>
Female	455	302		
Male	377	384		
Age			1.11	0.290
<60 years (young/middle-aged adult)	631	536		
≥60 years (elderly)	201	150		
BMI			35.15	<b>&lt;0.001</b>
≤23.9 (normal)	477	494		
≥24 (overweight/obese)	355	192		

Highly significant *p* values are shown in bold.  
GERD, gastroesophageal reflux disease.

shared by majority of the GERD patient group. Eating foods hotter than 60°C was also common.

Univariate analysis with Chi-square tests indicated that the demographic factors of being male and having a BMI >24 (Table 3) as well as 18 lifestyle habits (smoking, drinking, fast eating, eating beyond fullness, eating food too hot, preference for drinking soup, preference for spicy foods, preference for high-fat foods, preference for acidic foods, preference for sweets, preference for hard foods, preference for strong tea, preference for coffee, lying down soon after eating, eating just before bedtime, difficulty with defecation, sleep difficulties, feeling stress continually, and wearing girdles or corsets; Table 4) were associated with the presence of GERD symptoms. As reported in Figure 2, logistic regression analysis of risk factors reported being related to GERD in the univariate analysis implicated the following habits as risk factors (more to less robust): fast eating, eating beyond fullness, wearing girdles or corsets, eating food too hot, BMI above normal, lying down soon after eating, and smoking.

#### Treatment efficacy

Of 832 patients, 699 completed the 6-month follow up, yielding a successful follow-up rate of 84.01%; 133 people were lost to follow up,

primarily due to personal factors and contact information changes. All patients with GERD were treated with standardized drug therapy (PPI test) and guided to correct bad habits. Of the 699 patients in the GERD group who were followed up successfully for 6 months, 326 (46.6%) experienced significant efficiency and 332 (44.5%) experienced marginal efficacy, yielding a total effective rate of 658/699 (94.1%). The lifestyle observation subgroup (patients who heeded all lifestyle recommendations) included 464 GERD patients, a majority of whom (264/464; 56.9%) had substantial treatment efficacy. Many patients in the observation subgroup (192/464; 41.4%) had moderate treatment efficacy, while relatively few (8/464; 1.7%) had invalid treatment outcomes. The fully followed-up lifestyle control subgroup (patients who maintained some bad habits), included 235 GERD patients, only about a quarter of whom (62/235; 26.4%) had substantial treatment efficacy. A majority of the control subgroup patients (140/235; 59.6%) had moderate treatment efficacy, while the remainder (33/235; 14.0%) had invalid treatment outcomes. Mann–Whitney rank sum test results indicated that the lifestyle observation subgroup patients had better relief after 6 months than those in the control subgroup, with both subgroups receiving medication (Mann–Whitney  $U = 35276.000$ ,  $Z = -8.578$ ,  $p < 0.001$ ). The average ranks of the

**Table 4.** Univariate analysis of lifestyle risk factors for GERD.

Lifestyle factor	Number in group				$\chi^2$	<i>p</i>
	GERD		Non-GERD			
	No	Yes	No	Yes		
Smoking	543	289	564	122	54.72	<0.001
Drinking	597	235	588	98	42.79	<0.001***
Fast eating	169	663	442	244	304.31	<0.001***
Eating beyond fullness	264	568	496	190	247.57	<0.001***
Eating too-hot food	461	371	538	148	88.53	<0.001***
Preference for soup	395	437	374	312	7.46	0.006**
Preference for spicy food	322	509	398	288	56.79	<0.001***
Preference for high-fat foods	412	418	516	170	105.19	<0.001***
Preference for acid food	544	287	562	124	52.38	<0.001***
Preference for sweets	396	435	416	270	26.31	<0.001***
Preference for hard food	537	294	574	112	70.43	<0.001***
Preference for strong tea	600	232	604	604	58.17	<0.001***
Preference for coffee	719	113	650	36	29.5	<0.001***
Lying down soon after eating	516	316	542	144	51.39	<0.001***
Eating just before bedtime	23	209	554	132	7.46	0.006**
Difficulty defecating	662	170	594	2	12.98	<0.001***
Sleep difficulties	498	334	468	218	11.37	0.001**
Feeling stress continually	401	431	406	280	18.23	<0.001***
Wearing girdles or corsets	676	156	646	40	55.81	<0.001***

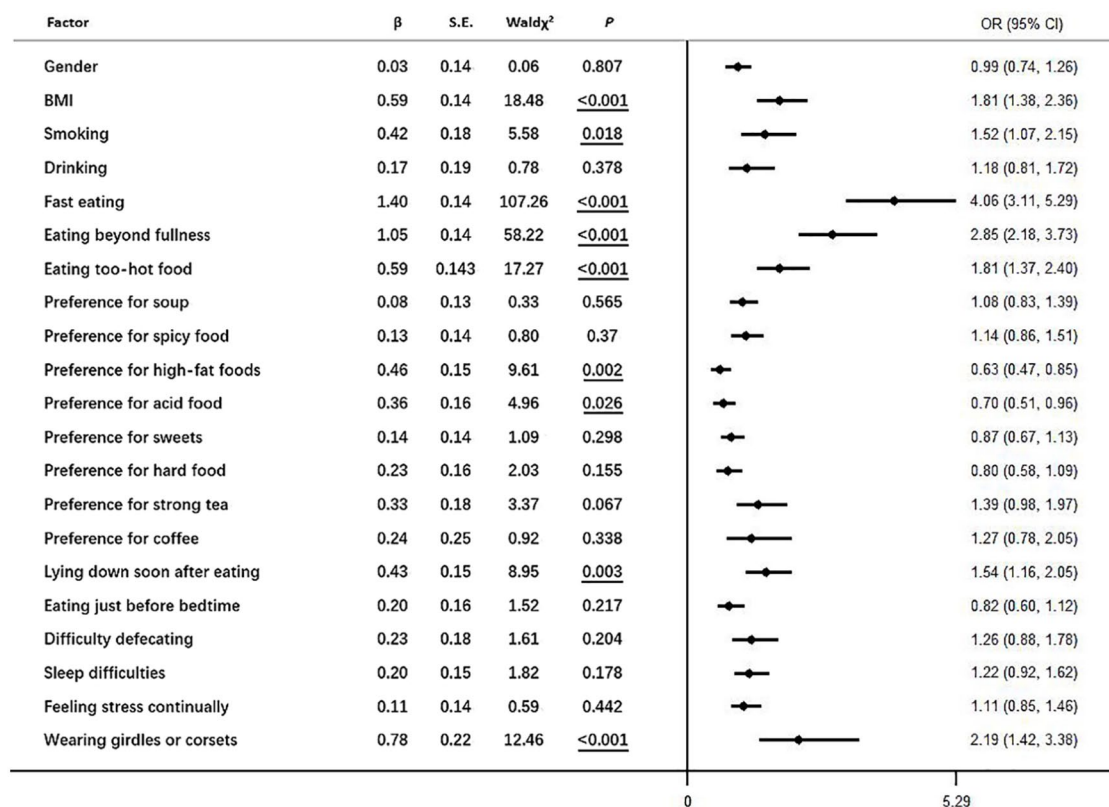
Significance levels: \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .  
GERD, gastroesophageal reflux disease.

observation and control subgroups were 308.53 and 431.89, respectively.

## Discussion

In the present study, we demonstrated that the top lifestyle elements favoring GERD were fast eating, eating beyond fullness, and preference for spicy food. Logistic multiple regression analysis implicated fast eating, eating beyond fullness,

wearing girdles or corsets, eating too-hot foods, a BMI >24, lying down soon after eating, and smoking as contributors to GERD symptoms. Mann–Whitney rank sum tests indicated that medication was more effective for GERD symptom alleviation when combined with lifestyle interventions, which is consistent with the results of several studies involving lifestyle interventions in GERD. For instance, Eivind Ness-Jensen's studies suggested that weight loss and tobacco



**Figure 2.** Multivariate analysis of GERD-related risk factors. Underline indicates  $p < 0.05$ . GERD, gastroesophageal reflux disease.

smoking cessation could be great recommendations, and avoiding late evening meals decreased time of supine acid exposure.<sup>19</sup> The American College of Gastroenterology (ACG) guideline (2013) also recommended weight loss for GERD patients with overweight or recent weight gain.<sup>20</sup> Concerning dietary patterns, predominantly Mediterranean (frequent consumption of composite/traditional dishes, fresh fruit and vegetables, olive oil, and fish) was reported as having a beneficial effect in the occurrence of GERD *versus* largely non-Mediterranean (frequent consumption of red meat, fried food, sweets, and junk/fast food).<sup>21</sup> However, few studies on dietary habits in the literature including eating, eating beyond fullness and eating too-hot foods, which are subjective indicators needing objective definition and a large number of RCTs. Lower GERD incidence in females may be relevant to estrogen inactivating inflammatory cells, thereby delaying GERD progression.<sup>22</sup> Although GERD incidence has been reported to raise with age,<sup>23</sup> GERD prevalence did not differ between our young/middle-aged adults and elderly adults.

GERD appears to have a multifactorial etiology,<sup>24</sup> and it has been supposed that poor dietary habits and lifestyle factors may induce or aggravate GERD symptoms. The recent growth in GERD among young adult and middle-aged Chinese people is thought to have something to do with dietary changes, acceleration in the pace of work expected, and chronic stress. Epidemiological studies have pointed to an association between a high BMI and GERD.<sup>25</sup> GERD in overweight people may be relevant to gastric overfilling, which can loosen the lower esophageal sphincter (LES) and cause hiatal hernia.

Our findings that GERD symptoms were interlocked with cigarette smoking, drinking of alcohol, consumption of spicy, fatty, acidic, sweet, and hard foods are consistent with physiological studies<sup>26–28</sup> showing reduced esophageal pressure, accelerated gastric peristalsis, augmented secretion, delayed mucosal nerve-stimulated gastric emptying, augmented esophageal acid exposure, and aggrandized inflammation in relation to these food habits. Our discoveries of a connection



between strong tea drinking and GERD stay in alignment with some other studies involving Chinese subjects,<sup>29</sup> though others have failed to find drinking of strong tea to be a significant risk factor for GERD.<sup>30</sup> Theophylline, a major component of tea, can ease LES<sup>31</sup> and alleviate visceral discomfort.<sup>32</sup> The inconsistency of results with respect to tea drinking may be related to differences in tea type, production/processing, and additives, as well as cultural differences related to tea consumption.

Keeping in step with the present study's insights into the link between coffee drinking and GERD symptoms, the results of a double-blind crossover study pointed to an association between coffee intake and GERD reflux.<sup>33</sup> Conversely, the results of a single-oval twin study suggested that coffee may reduce the occurrence of GERD.<sup>34</sup> A meta-analysis did not confirm a relationship between coffee intake and GERD.<sup>35</sup> It is our view that coffee may increase gastric acid secretion by encouraging gastrin excretion, thereby promoting transient LES looseness, which may contribute to the development of GERD by delaying gastric emptying.<sup>36</sup>

The most striking findings in our research were related to three factors: fast eating, eating beyond fullness, and eating very hot foods. Research on these three factors is quite limited at present. Regarding the reasons that these behaviors may induce or aggravate the onset of GERD, it may be that swallowing large, rough boli subjected to limited chewing due to fast eating can do damage to the esophageal mucous membranes. Meanwhile, eating too fast also leads to the consumption of very large volumes, which can produce gastric pressure while irritating hydrochloric acid in gastric juice production and lessening LES rigidity and gastrointestinal motility. Because the gastric emptying rate is limited physiologically, mechanical and physiological factors induce an extended delay in the gastric emptying of a large food volume and may increase the risk of gastric contents spilling into the esophagus, promoting or aggravating the occurrence of GERD. Moreover, eating excessive amounts leads to overfullness, and, in the long term, obesity, which combines with multiple risk factors to accelerate disease progression. Very hot foods can destroy the esophageal mucosal defence directly. Our findings of an association between a preference for soup and GERD may reflect the combined effects of eating quickly

and eating very hot food. There is also a danger that people may add soup to a meal that was already calorically sufficient, leading to weight gain, which itself favors GERD.

The linkage of GERD with difficulty defecating and wearing tight girdles or corsets may be related to abdominal pressure. Refraining from lying down or going to bed shortly after eating and sleeping with the head elevated are key lifestyle interventions for GERD. The interconnection between sleep duration and GERD appears to be bidirectional,<sup>37</sup> and sleep can lead to esophageal hyperalgesia.<sup>38</sup> Hence, GERD patients will be prone to have difficulty falling and staying asleep if they are suffering from frequent reflux symptoms, and poor sleep can promote reflux, forming a vicious circle. GERD symptoms have been linked with psychosocial characteristics, such as obsessive-compulsive, interpersonal sensitivity, and phobias.<sup>39</sup>

In the treatment, we found that compared with patients without lifestyle interventions, GERD patients with lifestyle interventions had a significantly higher remission rate of symptoms under the same PPI treatment conditions. In another study, a prospective population-based cohort study demonstrated that decrease in BMI was dose-dependence linked to a reduction of gastroesophageal reflux symptoms, but also an increased chance of losing reflux symptoms with PPI treatment in the general population (OR 1.98, 95% CI 1.45–2.72 with >3.5 units decrease in BMI and no or less than weekly medication compared with OR 3.96, 95% CI 2.03–7.65 with >3.5 units decrease in BMI and at least weekly medication),<sup>40</sup> which is consistent with the findings of our research. A HUNT study reported that there was only an association between tobacco smoking cessation and gastroesophageal reflux symptoms status among individuals with severe reflux symptoms (adjusted OR 1.78; 95% CI: 1.07–2.97) of normal BMI (OR 5.67; 95% CI: 1.36–23.64) using anti-reflux medication at least weekly rather than other individuals with gastroesophageal reflux symptoms,<sup>41</sup> suggesting that lifestyle interventions lead to a superposition effect. Drugs may temporarily inhibit acid reflux, but the effects of bad habits on the disease are persistent and serious, so that the accumulation of bad living habits reduces the efficiency of drug treatment in GERD patients, and even accelerates the progress of the disease, as said 'A spark

can start a prairie fire'. To sum up, the efficiency of treatment can be significantly improved with the combination of medication and lifestyle interventions.

In conclusion, risk factors for GERD include fast eating, eating beyond fullness, wearing girdles or corsets, eating too-hot food, a BMI above the normal range, lying down soon after eating, and smoking. Lifestyle changes that address these factors, especially fast eating, eating beyond fullness, and eating too-hot food, which are rarely studied or discussed despite being common, may improve GERD management and treatment outcomes. It is important to gain a holistic impression of symptoms and their impact on quality of life because GERD diagnoses may be missed in patients who are suffering from symptoms in the absence of endoscopic signs of disease.

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### Author contributions

LZY wrote the paper; PY corrected and revised the text; GSW, SYT, GMH, LZQ, and YJ collected and analyzed data; FW designed the research, contributed to survey design, and conducted statistical analysis of the data. All authors contributed intellectually to the writing process and approved the final version of the manuscript.

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### Conflict of interest statement

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