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ORIGINAL ARTICLE—ALIMENTARY TRACT

Body mass index association with functional gastrointestinal disorders: differences between genders. Results from a study in a tertiary center

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Abstract

Background Obesity is considered as a risk factor for many functional gastrointestinal disorders. The aim of the study was to evaluate if functional digestive disorders are associated with specific body mass index groups and gender.

Methods A total of 1074 patients (50.3 ± 16.5 years, 67 % females) filled out a standard Rome III questionnaire (79 % acceptance rate). The patients were assigned to five groups according to their body mass index: underweight (6 %), normal (49 %), overweight (28 %), obese (12 %), and morbidly obese (5 %). Data analysis was performed using multinomial logistic regression; subjects with the normal weight were the reference group.

Results Patients presented specific demographic and clinical characteristics according to the weight groups.

- Underweight patients were younger ($p < 0.001$), and presented a female predominance ($p = 0.006$), dysphagia ($p = 0.013$) and soiling ($p = 0.021$).
- Overweight patients were older ($p = 0.001$), and reported more frequently globus ($p = 0.001$), regurgitation ($p = 0.004$), postprandial distress syndrome ($p = 0.009$).
- Obese patients reported more frequently regurgitation ($p < 0.001$).
- Morbid obese patients reported dyspepsia ($p = 0.046$).

In patients, the odds of regurgitation increased with body mass index from underweight to obesity, but not when compared to morbid obesity. The probability of globus and regurgitation increased with body mass index and presented a steeper increase in females.

Conclusions In patients with functional gastrointestinal disorders, globus and regurgitation are associated with body mass index, mainly in female patients.

Keywords Morbid obesity · Functional gastrointestinal disorders · Rome criteria · Regurgitation · Globus · Gender

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Introduction

Functional gastrointestinal disorders (FGIDs) are diagnosed with the use of symptom-based diagnostic criteria that have been developed (ROME III) for such disorders of multifactorial etiology with no specific biologic or histologic criteria and which cannot be explained by the presence of other disorders that could be present in the same digestive segment [1].

FGIDs are highly prevalent in the general population. Esophageal disorders are present in 20–40 % [2], dyspeptic symptoms in 20–30 % [3], bowel symptoms in 10–20 %

[4], abdominal pain in 0.5–2 % [5] and anorectal disorders in 2.2 to 15 % [6] of the population.

Epidemiologic studies have shown that 30 % of adults in the USA and as much as 10–25 % of adults in European countries are obese and that the incidence of obesity is increasing [7]. Data from epidemiological studies that estimate the prevalence of low BMI in adults are rare, excepting for anorexia nervosa in women aged 11 to 65 years in the general population, and its prevalence ranges from 0 to 2.2 % [8].

The association between obesity and FGIDs, two common disorders in the general population, has already been studied. Abdominal pain, irritable bowel syndrome (IBS), bloating, heartburn, and gastroesophageal reflux disease (GERD) symptoms are known to be more prevalent in overweight patients [9], and body mass index (BMI) had been positively associated with abdominal pain and diarrhea. In a recent study with patients eligible for bariatric surgery, we found that functional symptoms were reported in 89 % of the participants before surgery, but their symptoms were less specific [10].

In most studies, the clinical definition of the disease and the type of recruitment is not clearly described [11–15]. The aim of the present study was to evaluate the association between FGIDs and BMI groups used in clinical practice, in a large cohort of outpatients consulting for FGID in a tertiary hospital center specialized for this type of disease. Our hypothesis wass that specific functional gastrointestinal disorders are associated with BMI groups in FGID patients, and that gender might influence this association.

Methods and procedure

Subjects

From January 2008 until January 2014, 1365 outpatients were referred to the gastrointestinal unit of the Avicenne Hospital, a tertiary center for FGID management. Among them, 1074 consecutive outpatients that agreed to participate to the study and that have a full data set were included in the study. All patients gave informed consent. The study was declared in the French National Agency for drug safety (ANSM, Agence Nationale de Sécurité du Médicament et des produits de santé, decision number: A00886-43). Patients were referred by a gastroenterologist or a general practitioner after an initial symptomatic treatment that failed or for diagnostic purposes before starting a treatment.

The patients presented a female predominance (67 % female) and had a mean age of 50.3 ± 16.5 years (BMI 25.3 ± 5.4 kg/m^2). Before inclusion, a full evaluation failed to yield any organic cause for the patients' complaints, and patients were screened for bile malabsorption and eosinophilic esophagitis. Patients with neurologic disease such as stroke, spine trauma, multiple sclerosis were excluded from the study. Patients with endocrine diseases (hypercalcemia or thyroid diseases) or autoimmune diseases (scleroderma, rheumatoid polyarthritis, other autoimmune diseases or connective tissue disorders) were excluded at screening. Patients with chronic use of NSAIDs (more than once per month) were also excluded. Diabetic patients were referred to diabetes specialists (MF, RC) when diabetes was poorly controlled. Medications such as calcium channel inhibitors were assessed at the initial evaluation and a switch to a different antihypertensive treatment from another pharmacological class was prescribed. If symptoms improved, then the patient was excluded from the study since it was considered a side effect of his treatment. If symptoms remained, the patient was included in the study.

Patients also had a morphological evaluation (endoscopy or radiology). Patients with anorectal symptoms and symptomatic hemorrhoids were excluded, while patients with hemorrhoids that were not symptomatic (a very common finding) were included, but this was not registered in our database. Patients with anal fistula and abscess were also excluded. A gastric fibroscopy was performed in all patients with upper gastrointenstinal disorders, and if patients had an H pylori infection, they were excluded.

Patients with a history of previous surgery of the gastrointestinal tract, or drug or alcohol addiction, were excluded from the study. A single investigator (MB) confirmed independently, during the medical visit, the validity of the initial diagnosis of FGID. In addition, all overweight patients that participated in a specific program for losing weight, or used a gastric balloon or bariatric surgery, were excluded in order to avoid inducing a selection bias.

Experimental procedure

Study design

The current study is a prospective observational study.

Questionnaires

Patients filled out a standard clinical questionnaire based on diagnostic questions for FGIDs in the gastroenterologist's office during their visit [10]. The interpretation was based on the functional disorders as defined by the Rome III criteria.

- Functional esophageal disorders (heartburn, non-cardiac chest pain, dysphagia, globus) were diagnosed in

the absence of both gastroesophageal reflux and histopathology-based esophageal motility disorders [2]. In addition to the above-mentioned symptoms, regurgitation was recorded.

- Functional gastroduodenal disorders (dyspepsia, postprandial distress syndrome, epigastric pain syndrome, aerophagia) were diagnosed when there was no evidence for structural disease at upper endoscopy, abnormal behavior (self-induced vomiting, chronic cannabinoid use), central nervous system or metabolic diseases that could explain the symptoms [3].
- Irritable bowel syndrome (IBS) was diagnosed when recurrent abdominal pain or discomfort at least 3 days per month in the last 3 months was associated with two or more of the following: improvement with defecation, onset associated with a change in frequency of stool or with a change in form (appearance) of stool. Subtypes of IBS [IBS with constipation (IBS-C), IBS with diarrhea (IBS-D), mixed IBS (IBS-M) and unsubtyped IBS (IBS-U)] were defined according to the Rome III criteria [4]. Other functional bowel disorders (bloating, constipation, diarrhea, and unspecified) were diagnosed when the criteria for a diagnosis of IBS were insufficient or absent. Finally, non-specific bowel disorders were diagnosed by exclusion when patients did not meet the above-mentioned criteria.
- As indicated by Rome III criteria, establishing diagnosis for functional abdominal pain syndrome includes all of the following: continuous or nearly continuous abdominal pain, and no or only occasional relationship of pain with physiological events [5]. The patients did not present any symptoms that met the criteria for another FGID that would explain the pain.
- Functional anorectal disorders were divided into soiling, functional fecal incontinence, functional anorectal pain, including levator ani syndrome proctalgia fugax, and difficult defecation [6].

Group definition

The patients were classified into five groups according to their BMI (kg/m^2) [16]: (1) underweight (BMI $<$ 18.5); (2) normal weight (18.5 $\leq$ BMI $<$ 25); (3) overweight (25 $\leq$ BMI $<$ 30); (4) obese (30 $\leq$ BMI $<$ 35); (5) morbid obesity (BMI $\geq$ 35).

Statistical analysis

Statistical analyses were carried out using IBM SPSS (IBM SPSS Statistics v 20). The results were expressed as mean $\pm$ standard deviation (SD). Patients with missing data were excluded. Analysis of variance (ANOVA) with post hoc tests using the Bonferroni correction ($p < 0.01$) was used for analysis of quantitative variables and the Chi square test was used for analysis of qualitative variables among BMI groups.

A multinomial logistic regression model that included BMI group as a dependent variable coded from 1 (underweight group) to 5 (morbid obese group) and the functional gastrointestinal disorder, age, and gender as predictors was used for calculating the odds ratios of predictors relative to the normal BMI group. The backwards selection procedure was used for model selection during the logistic regression.

For each disorder, the slopes of the linear regression curves were compared using a t test.

Results

Patients characteristics by BMI group

The participants' demographics are summarized in Table 1. The majority of the studied patients ($n = 521$, 49 %) had normal weight, 6 % were underweight ($n = 69$) and 45 % had excessive weight ($n = 484$), that is overweight, obese or morbid obese. Female patients represented 67 % ($n = 718$) of the studied group and were more present in the underweight group. Inversely, the highest proportion of males was found in the overweight group compared to the other groups (44 %, $p < 0.001$). Patients were also younger in the underweight group ($p < 0.001$ vs. all other groups).

Relationship between weight groups and functional disorders

Patients' symptoms were associated with 2.5 $\pm$ 1.1 digestive sites. Among, the different sites, the frequency of complaint, defined as at least one symptom per site, was not significantly different for all sites ($p = 0.339$). The prevalence of the different functional disorders is summarized in Table 1. Significant changes in the distribution among groups were found for two esophageal symptoms: globus and regurgitation.

Globus was a more frequent finding in overweight patients ($p = 0.003$), and regurgitation, more frequent in the overweight and in the obese groups ($p < 0.001$ for each group). In contrast, no difference was found for gastroduodenal disorders.

For functional bowel disorders, the frequency of two pathologies changed with the BMI group: IBS with constipation (IBS-C) and functional diarrhea. IBS-C was more

Table 1 Demographic and frequency of functional disorders according to the BMI groups

	Total	Underweight	Normal weight	Overweight	Obese	Morbidly obese	*p*
Demographic							
N (%)	1074 (100 %)	69 (6 %)	521 (49 %)	303 (28 %)	130 (12 %)	51 (5 %)	
BMI (kg/m^2)	25.3 ± 5.2	17.1 ± 1.2	22.2 ± 1.8	27.2 ± 1.4	32.0 ± 1.4	39.1 ± 3.6	
Gender (% female)	718 (67 %)	58 (84 %)	349 (67 %)	176 (58 %)	93 (72 %)	43 (83 %)	<0.001
Age	50.3 ± 16.5	40.1 ± 15.5	48.7 ± 17.3	53.6 ± 15.3	53.0 ± 13.9	53.5 ± 14.0	<0.001
Functional esophagus disorders							
Globus	230 (21 %)	13 (19 %)	87 (17 %)	85 (28 %)	33 (25 %)	12 (23 %)	0.003
Regurgitation	167 (16 %)	6 (9 %)	59 (11 %)	60 (20 %)	33 (25 %)	9 (17 %)	<0.001
Chest pain	314 (29 %)	15 (22 %)	152 (29 %)	95 (31 %)	39 (30 %)	13 (25 %)	0.555
Heartburn	406 (38 %)	25 (36 %)	179 (34 %)	135 (45 %)	49 (38 %)	18 (35 %)	0.069
Dysphagia	280 (26 %)	26 (38 %)	133 (26 %)	72 (24 %)	38 (29 %)	11 (21 %)	0.133
Functional gastroduodenal disorders							
Epigastric pain	98 (9 %)	8 (12 %)	44 (8 %)	35 (12 %)	7 (5 %)	4 (8 %)	0.262
Postprandial distress	206 (19 %)	14 (20 %)	94 (18 %)	69 (23 %)	21 (16 %)	8 (15 %)	0.375
Nonspecific dyspepsia	287 (27 %)	19 (28 %)	132 (25 %)	82 (27 %)	35 (27 %)	19 (37 %)	0.545
Aerophagia	284 (26 %)	19 (28 %)	138 (27 %)	76 (25 %)	37 (28 %)	14 (27 %)	0.962
Functional bowel disorders							
IBS constipation	77 (7 %)	3 (4 %)	49 (9 %)	21 (7 %)	2 (2 %)	2 (4 %)	0.018
IBS diarrhea	11 (1 %)	0 (0 %)	7 (1 %)	2 (1 %)	2 (2 %)	0 (0 %)	0.641
IBS mixed	46 (4 %)	3 (4 %)	24 (5 %)	12 (4 %)	6 (5 %)	1 (2 %)	0.916
IBS unspecified	16 (1 %)	0 (0 %)	7 (1 %)	4 (1 %)	4 (3 %)	1 (2 %)	0.482
Constipation	227 (21 %)	19 (28 %)	120 (23 %)	50 (17 %)	28 (22 %)	10 (19 %)	0.141
Diarrhea	11 (1 %)	3 (4 %)	3 (1 %)	4 (1 %)	0 (0 %)	1 (2 %)	0.032
Bloating	122 (11 %)	11 (16 %)	62 (12 %)	32 (11 %)	12 (9 %)	5 (10 %)	0.638
Nonspecific bowel disorders	261 (24 %)	11 (16 %)	123 (24 %)	76 (25 %)	35 (27 %)	16 (31 %)	0.342
Functional abdominal pain	283 (26 %)	20 (29 %)	125 (24 %)	83 (27 %)	39 (30 %)	16 (31 %)	0.515
Functional anorectal disorders							
Soiling	90 (8 %)	8 (12 %)	36 (7 %)	33 (11 %)	9 (7 %)	4 (8 %)	0.263
Fecal incontinence	92 (9 %)	6 (9 %)	39 (8 %)	26 (9 %)	14 (11 %)	7 (13 %)	0.533
Levator Ani syndrome	66 (6 %)	1 (1 %)	29 (6 %)	23 (8 %)	9 (7 %)	4 (8 %)	0.357
Proctalgia Fugax	64 (6 %)	6 (9 %)	30 (6 %)	15 (5 %)	9 (7 %)	4 (8 %)	0.736
Nonspecific anorectal disorders	47 (4 %)	1 (1 %)	34 (7 %)	4 (1 %)	6 (5 %)	2 (4 %)	0.007
Obstructed defecation	382 (36 %)	22 (32 %)	189 (36 %)	105 (35 %)	48 (37 %)	18 (35 %)	0.941

BMI body mass index, *IBS* irritable bowel syndrome

frequent in patients with normal weight ($p = 0.018$), and less frequent in patients from the obese group. Functional diarrhea was found more frequently in the underweight group ($p = 0.032$), but this concerned only a small number of patients. Of the functional anorectal disorders, nonspecific anorectal disorders were the only disease that decreased among BMI groups: it was more frequent in patients from the normal BMI group ($p < 0.01$) and less frequent in patients of the overweight group ($p = 0.007$).

Patients with normal BMI (group 2) were the reference group in a multinomial logistic regression model (Table 2).

- FGID underweight patients had increased odds for reporting dysphagia [$p = 0.013$; OR = 2.238; 95 % CI = (1.186–4.223)] or soiling [$p = 0.021$; OR = 3.005; 95 % CI = (1.179–7.660)].
- FGID overweight patients had increased odds for reporting the presence of globus [$p = 0.001$; OR = 1.990; 95 % CI = (1.343–2.947)], regurgitation [$p = 0.004$; OR = 1.932; 95 % CI = (1.227–3.040)], and postprandial distress syndrome [$p = 0.009$; OR = 1.771; 95 % CI = (1.154–2.717)]. They had less odds to report dysphagia [$p = 0.003$; OR = 0.549; 95 %

Table 2 Significant results of the multinomial logistic regression (odds ratio are given by comparison to the normal BMI group)

Groups	Variables	*p*	Odds ratio	95 % CI	
Underweight	Age	<0.001	0.964	0.947	0.982
	Gender	0.006	2.689	1.320	5.478
	Dysphagia	0.013	2.238	1.186	4.223
	Soiling	0.021	3.005	1.179	7.660
Overweight	Gender	0.003	0.608	0.437	0.846
	Age	0.001	1.017	1.007	1.027
	Globus	0.001	1.990	1.343	2.947
	Regurgitation	0.004	1.932	1.227	3.040
	Dysphagia	0.003	0.549	0.371	0.813
	Postprandial distress	0.009	1.771	1.154	2.717
	Non specific anorectal disorders	0.002	0.173	0.059	0.513
Obese	Age	0.046	1.013	1.000	1.026
	Regurgitation	<0.001	2.717	1.554	4.752
Morbid obesity	Dyspepsia	0.046	2.174	1.013	4.666

BMI body mass index

CI = (0.371–0.813)] and nonspecific anorectal pain [$p = 0.002$; OR = 0.173; 95 % CI = (0.059–0.513)].

- Obese FGID patients had increased odds for reporting regurgitation [$p < 0.001$; OR = 2.717; 95 % CI = (1.554–4.752)].
- Morbid FGID obese patients had increased odds for reporting non-specific dyspepsia [$p = 0.046$; OR = 2.174; 95 % CI = (1.013–4.666)].

Psychometric evaluation

The depressive symptoms index was different among groups ($p = 0.022$) and formed a U curve from the lowest to the highest BMI group, respectively (12.8 ± 11.6, 11.3 ± 9.7, 11.4 ± 9.1, 13.9 ± 13.0, 15.9 ± 9.8). The A1 index for stare anxiety and A2 for trait anxiety were not different among groups ($p = 0.816$ and $p = 0.995$).

Relationship between functional disorders and BMI, as a continuous variable: the role of gender

The association between BMI and the two significant functional esophageal disorders, globus and regurgitation, was adjusted for gender and BMI as a continuous variable. Figure 1 shows that female patients have a higher probability of reporting globus than male patients for the same BMI, independent of the BMI group. In addition, the slope of the curve was higher in females than in males ($p < 0.001$). Figure 2 shows the relationship between the probability of regurgitation and the BMI. Figure 2 also shows that the probability to report regurgitation is only higher for females with high BMI as compared to male FGID patients. Here again, the slope of the linear regression is higher in females than in males ($p < 0.001$).

Discussion

This study was conducted in a tertiary referral center, and has shown that, among FGID patients, BMI groups are associated with specific FGIDs. Compared to patients with a BMI in the normal range, underweight patients are younger while overweight and obese patients are older, and there is female predominance across all groups. Globus was more frequent in the overweight patients, while the odds of regurgitation increased in the overweight and the obese group. Furthermore, female patients had increased odds of globus and regurgitation than male patients.

In contrast to epidemiological studies [9] that have examined the prevalence of symptoms in the general population, patients included in this study have consulted only for management of FGIDs in a specialized tertiary center diagnosis, and the follow-up of FGIDs was performed by the same person (MB). This approach has shown a very good reproducibility in our questionnaires [17]. This also explains why results from the present study are not similar to a previously published paper on patients eligible for bariatric surgery [18]. Most studies reporting on the relationship between digestive disorders and BMI were frequently limited to one type of complaint, gastro-esophageal reflux [18] or constipation [19]. Moreover, there was no distinction among the different groups of patients with increased BMI, that is, overweight patients, obese patients, and morbidly obese patients [19]. All obese patients that had participated in a specific program to reduce weight with the use of gastric balloon or bariatric surgery were not included in the present study.

As expected, dysphagia was a positive predictor for the underweight group [19]. For these patients, a full evaluation was performed, including blood samples, esophageal

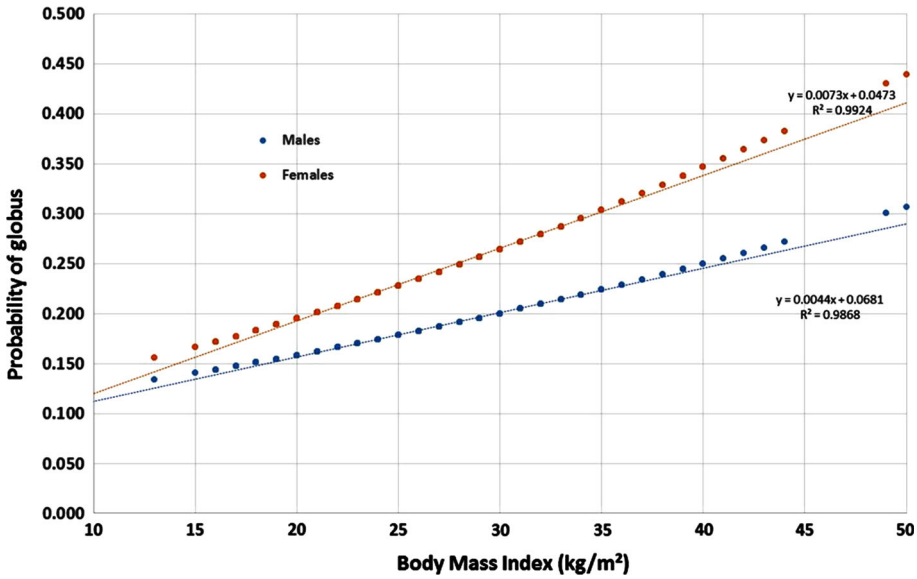

Fig. 1 Relationship between the probability of globus and body mass index according to gender

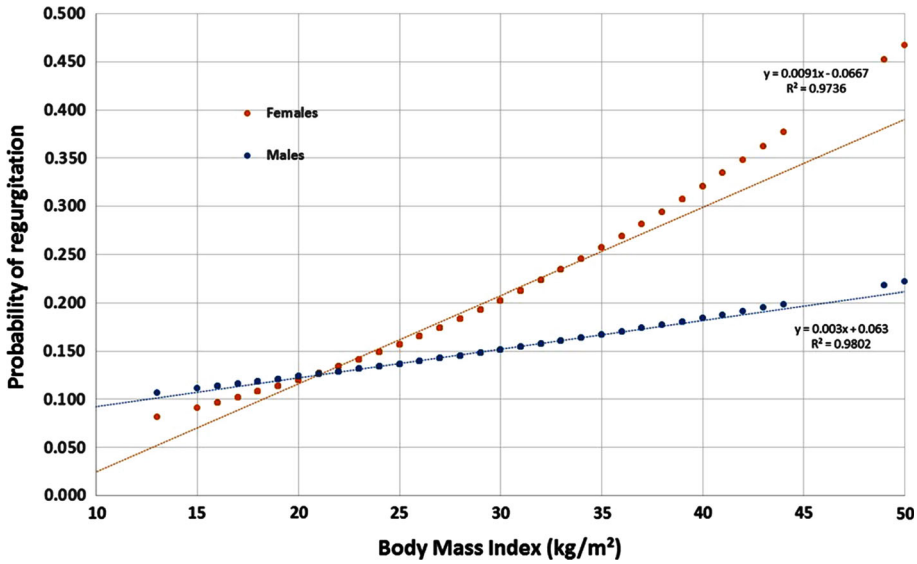

Fig. 2 Relationship between the probability of regurgitation and body mass index according to gender

endoscopy and esophageal motility tests for obstruction, ring or motility disorders. The mean follow-up period was 6 months and the normality of these tests cannot eliminate a late manifestation of a systemic disease like scleroderma or other mixed connective tissue disease, with dysphagia being its first symptom. However, this is an unusual manifestation of a relatively rare disease and it is not likely that it could have an impact in this group. The presence of anorexia nervosa was also excluded by psychiatric interview when that was necessary. In this group, significant associations were found with female gender and young age. Limited food intake could explain its high prevalence in the low BMI group, but the occurrence of body shape and size dissatisfaction, as frequently reported in young people, might also contribute [20].

In FGIDs patients, overweightness is associated with globus, regurgitation, and postprandial distress syndrome, while obesity is only associated with regurgitation. Classically, a high BMI is associated with an elevated risk of gastroesophageal reflux disease (GERD), and the relationship between increasing BMI and prevalence of GERD has also been demonstrated [21]. The high intragastric pressure found in obese patients represents one physiopathologic hypothesis to explain this epidemiologic association [22]: this elevation of intragastric pressure increases retrograde flow through the esogastric junction and/or promotes the development of hiatus hernia.

Previous studies have shown that in GERD patients, higher BMI was associated with more severe and more frequent reflux symptoms and esophagitis [23]. Despite the

important number of patients included in previous studies, the patients were divided in a limited number of BMI groups [24]. Our results do not fully support the above-mentioned mechanism and the results of previous studies. The prevalence of regurgitation, the most suggestive symptom of GERD [24], increased with the BMI from the underweight group to the obese group, but decreased in morbidly obese patients. Heartburn was reported in overweight patients, but not in groups of patients with higher BMI. The results of the present study are in agreement with recent studies in morbid obese patients: a French study has shown no relationship between GERD and BMI or abdominal diameter [25], and two Spanish studies showed that asymptomatic GERD was more common than symptomatic GERD in severely obese patients [26] and that heartburn complaint was independent of BMI [27]. These studies suggested the existence of other factors associated with the dramatic increase of BMI: the secretion of visceral fat adipo-cytokines, interleukin-6 and tumor necrosis factor α [28], could play a major role in GERD [29].

The association of dyspepsia with obesity has already been reported [30]. In the current study, the epigastric pain syndrome was a nonsignificant positive predictor for overweight, and nonspecific dyspepsia was a nonsignificant positive predictor for morbid obesity (Table 2). Epidemiological studies based on the frequency of symptoms provided discordant results. A positive relationship between BMI $>$ 30 kg/m^2 and frequent vomiting or upper abdominal pain was found [9], while another study found that postprandial fullness, nausea and vomiting were not associated with BMI categories, but early satiety was associated with a lower BMI [31]. A previous Swedish study showed a significant association between obesity (>30 kg/m^2) and epigastric pain [24]. The present study was not based on reported symptoms, but on the presence of FGID disorders in patients seeking medical treatment for their disease. This could explain the poor relationship between BMI groups and gastroduodenal functional disorders.

Some FGIDs are negative predictors for BMI groups and represent a mirror reflection of BMI's positive predictors. For example, dysphagia, a positive predictor for underweight, was a negative predictor for overweight. Similarly, the present study shows that diarrhea (IBS-D and functional diarrhea) is more frequent in the different groups in weight excess, while constipation is more frequent in normal weight patients, confirming studies that have shown decreased digestive transit with high BMI [32].

A previous meta-analysis has shown a significant association between obesity and chest pain/heartburn [33]. In the present study, chest pain and heartburn are two distinct disorders, and have different relationships to BMI [34]: 7.6 % of the patients reported regurgitation and chest pain at the same time (chest pain only 20.1 % vs. 6.7 % for regurgitation only, $p < 0.001$). In an American and in an Australian cohort, the presence of a BMI $>$ 30 kg m^2 was associated with bloating [9]. The present study did not confirm these results, since in this paper, functional bloating was dissociated from IBS, but it confirms the result of a recent metaanalysis that found that functional abdominal pain was not associated to a specific BMI group [33].

One of the weak points of our study is that data for ethnic origin were not collected since it is not permitted by the French legislation, and data for specific eating habits with food questionnaires comorbidities and smoking were also not available.

The "globus sensation" is a feeling of a lump or tightness in the throat. An important finding of this study is that the odds of globus increased with BMI, and we confirm the higher prevalence of globus in female than in male FGID patients [35].

The probability of regurgitation increased with BMI and was more frequent in females. This result was previously found in dyspeptic patients. In these patients, gender was more important that gastric emptying in symptom severity of dyspepsia [36]. This study also showed a significant correlation between BMI and minimal distending pressure during the barostat procedure [36]. This result could be explained by the delayed gastric emptying found in females compared to male subjects for liquid or solid foods [37]. A recent study also showed that female gender, obesity, and sleepiness were related to prevalence of gastroesophageal reflux disease in obstructive sleep apnea syndrome patients [38].

One of the strong points of the present study is that it is a patient cohort, since our study was not performed in the general population, as in epidemiological studies where questionnaire reproducibility was not sufficient [39] and the organic nature of the symptoms could not be explored. The high prevalence of small intestinal bacterial overgrowth in obese patients that has been previously reported [40] was not found in the present study, since any patients with intestinal bacterial overgrowth were previously treated and excluded from our cohort. The present study has showed that the morbid obesity group had significant lower prevalence of regurgitation. That is because the odds for having regurgitation in this group decreased, instead of increasing as expected, and did not represent the upper extreme of the BMI continuum, as seen in Fig. 1.

In conclusion, in FGID patients, BMI groups were characterized by specific FGIDs. Dysphagia was more prevalent in patients with low BMI, while regurgitation, globus, heartburn, and postprandial distress were increased in overweight patients and increased regurgitation was found in obese patients. Additionally, the odds of globus and regurgitation increased with the increase of BMI, and

showed a steeper increase in females. We think that the presence of unusual BMI-related symptoms should drive to further investigations, i.e,. reported dysphagia in obese patients. Further studies are necessary to understand the mechanisms of the association of BMI with the related symptoms, and to elucidate their relationship with gender and common behavioral, hormonal, neuronal or mechanical pathways that might also regulate BMI.

Compliance with ethical standards

Conflict of interest Authors must indicate whether or not they have a financial relationship with an organization that sponsored the research. They should also state that they have full control of all primary data and that they agree to allow the journal to review their data if requested.

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