



Prevalence of Small Intestinal Bacterial Overgrowth in People with Gastrointestinal Signs and Symptoms Using Glucose Breath Test

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Abstract

Small intestinal bacterial overgrowth (SIBO) is a condition characterized by high bacterial population in small intestine. Its overall worldwide prevalence is unknown due to under diagnosis and unspecific symptoms. In clinical setup, diagnosis of SIBO is still a big challenge. Aspiration and breath tests are two possible diagnostic tests. The study objective was to find prevalence of SIBO in individuals using Glucose H₂ and CH₄ breath tests and to develop association of SIBO with age, gender, BMI, food and exercise. Total 385 individuals participated in study. Initial screening was done using symptomatic questionnaire, filled by respondents in an interview style to find out suspected individuals. Total sum of each symptom was calculated. Individuals with total score of ≥ 5 were considered suspected for SIBO and further proceeded for confirmation through Glucose Breath Test (GBT) using 50g glucose in 200 mL water. Individuals having at least 12 ppm increase in H₂ and / or CH₄ over the lowest preceding value or the basal reading within test period, were considered as positive for SIBO. Chi-square test was applied to find correlation between various factors. P value < 0.05 was considered as significant. On the basis of screening, 14.02% individuals were found suspected to have SIBO on the basis of positive gastro-intestinal signs and symptoms. In overall tested population, 4.42% individuals were observed as SIBO positive, 9.61% were false positive and 85.97% were negative for SIBO. Prevalence was high among individuals consumed starchy food (70.6%) and did not performed exercise (65%). There is no association of SIBO with age, gender and BMI. It can be concluded that SIBO is present among individuals with gastro-intestinal signs and symptoms. Testing SIBO with both H₂ and CH₄ gave better possible results as compared to individual gas testing.

Keywords: Small Intestinal Bacterial Overgrowth; Glucose Breath Test; H₂ Breath Test; CH₄ Breath Test; Gastro-intestinal Sign and Symptoms

Introduction

Digestive system is one of the most complex systems of living beings having microorganisms of several kinds along its length called gastrointestinal (GI) microbiota [1]. A balanced microbiota ecosystem is responsible for supplying, synthesizing and digestion

of essential nutrients and regulating enteric nervous system [2] as well as the maturation of immune system [3]. Healthy individuals have minimum bacterial count 10³ CFU/mL in their digestive system [4] but sometimes this balance disturbs and microflora exceed the normal limit and creates a condition called Small Intestinal Bac-

terial Overgrowth (SIBO) in which bacterial population in the small intestine becomes high i.e. $\geq 10^6$ CFU/mL [5]. Antibiotic therapies, stress, illness, aging, poor dietary and lifestyle habits causes imbalance [6]. Its symptoms include abdominal pain, flatulence, bloating, dyspepsia, fatigue, nausea, diarrhea, and constipation [7]. SIBO is one of the major causes of many chronic diseases like obesity, cancer, inflammatory bowel disease and autism [8]. Underlying diseases such as Parkinson’s disease, hypothyroidism, diabetes mellitus also increases the risk of SIBO due to a decrease in intestinal motility and increased gastric stay [9]. This disturbance in ecological balance resulting a change in proteolytic and saccharolytic fermentation which leads to the production of various metabolites including methane and hydrogen gases. It is also evident that the treatment of SIBO or methane breath eradication is strongly associated with improvement in lipid profile and insulin level in prediabetic obese subjects [10].

In healthy individuals, its prevalence is 2.5% to 22% [11] while in healthy elders 14.5% prevalence of SIBO has been reported [12]. Similarly, 20% prevalence has been reported in healthy asymptomatic individuals [13]. Its prevalence increases in the presence of other diseases like chronic pancreatitis 50-60% [14], 56% in cystic fibrosis patients [15], 60% patients with gastroparesis [16], 9-55% patients with celiac disease [16], 59% patients with diverticulitis and 25% in patients with Crohn’s disease [17]. In diabetes, 50-70% of gastro-intestinal symptoms occur due to SIBO [18]. The prevalence of SIBO increases with age, it is present in 50% of people older than 75 years old [19]. Despite having serious concerns, documented data regarding the individual prevalence of SIBO is very scarce. The exact estimate of the prevalence of SIBO is unknown worldwide due to under-diagnosis and unspecific symptoms. There are various reasons for its under-diagnosis, most common of them are ignorance and negligence of people; they may not seek health care or go to the hospital or physician [20]. Another reason is that they may not be properly diagnosed by medical facilities or investigations or the symptoms remain invisible [21]. The diagnosis of SIBO is usually based on either invasive or non-invasive tests. The invasive test requires aspirate whereas non-invasive test requires breath of the patient. A Hydrogen Breath Test (HBT) is more common practice as it is more sensitive and specific [22] but 8-27% of individuals do not produce hydrogen due to the presence of methanogenic bacterium like *Methanobacterium bryantii*, *M. formicum* etc. [23]. So that Methane Test (MT) is more sensitive

as compared to the HBT [24]. Keeping in mind previous observations, this study was planned with the objective to find the prevalence of SIBO using Glucose Breath Test (GBT) measuring H_2 and CH_4 , to develop an association of SIBO with age, gender, BMI and to find the relation of SIBO positive individuals with gastro-intestinal signs and symptoms.

Material and Methods

Present study was conducted at the Human Nutrition Clinic, Department of Food Science and Human Nutrition, University of Veterinary and Animal Sciences (UVAS), Lahore. The study protocol was approved by Human Bio-Ethical Committee, UVAS vide office letter no.005/IRC/BMR. Written consent was taken from the participants before start of study. The sample size was calculated according to formula i.e. $n' = NZ^2P(1-P)/d^2(N-1)+Z^2P(1-P)$ whereas, n' = Sample size with finite population correction, N = Population size, Z = Z statistic for a level of confidence, E = Expected prevalence and d = precision (if precision is 5% than $d = 0.05$) [25]. The study was conducted in five steps. Firstly, initial screening was done on the basis of inclusion and exclusion criteria followed by screening on basis of the Symptoms Questionnaire (Figure a). After that calculation of the total mean score, counseling of the respondent and GBT was done.

ID: _____								
Name: _____								
Age (years): _____								
Height (cm): _____								
Weight (kg): _____								
								Total Mean Score:
1. Do you feel abdominal pain, distention, cramps after eating something or having meal?								
2. Do you feel belching (act of expelling air from the stomach through the mouth)?								
3. Do you feel bloating (abdominal discomfort) after eating something or having meal?								
4. Do you feel fullness before or after eating something or having meal?								
5. Do you feel indigestion (dyspepsia-discomfort centered in the upper abdomen) after eating something or having meal?								
6. Do you feel nausea before or after eating something or having meal?								
7. Do you usually have diarrhea?								
8. Do you usually have vomiting before or after eating something or having meal?								
9. Do you usually have gas trouble before or after eating something or having meal?								
If answer of the question is yes, rate each question on the basis of intensity, frequency and duration.								
a. What is the intensity of symptom?								
a) 0= no symptom b) 1= mild c) 2=moderate d) 3= severe								
b. If yes, how frequently do you have symptom?								
a) 0= none b) 1=<1 episode/wk. c) 2= 1 episode/wk... d) 3=>1 episode/wk.								
c. What is the duration of symptom you usually have?								
a) 0= none b) 1=<10 min c) 2=10-30 min d) 3= >30 min								
Total Score:								
Q1:	Q2:	Q3:	Q4:	Q5:	Q6:	Q7:	Q8:	Q9:

Figure a: Symptomatic Questionnaire.

Initial screening

Total 385 respondents were screened on the basis of inclusion and exclusion criteria. According to inclusion criteria, participants

having age 18 years and above, non-hospitalized, non-diabetic, without any significant co-morbid medical problems like stroke, Coronary Obstructive Pulmonary Disease (COPD), cancers, and diabetes mellitus, without a history of previous GI surgeries except for cholecystectomy, hysterectomy and appendectomy were included in the study.

Screening of the respondents on the basis of symptom questionnaire

A symptoms questionnaire was developed as described by Erdogan., *et al.* [7] for the screening of signs and symptoms of SIBO (Figure a). All the participants who fulfilled the inclusion criteria for screening were interviewed to fill the symptomatic questionnaire based on 9 (nine) symptoms associated with SIBO including abdominal pain (cramps, distention), belching, bloating, feeling of fullness (before and after eating), indigestion, nausea, diarrhea, vomiting, and gas trouble. If any of these signs and symptoms were present then respondents were asked to rate it according to frequency, intensity and duration on a Likert scale (Table 1).

Score	Intensity of Symptom	Frequency of Symptom	Duration of Symptom
0	No symptom	None (absence of symptom)	None
1	Mild	<1episode/wk.	<10 min
2	Moderate	1 episode/wk.	10 min-30 min
3	Severe symptoms	>1 episode/wk.	>30 min

Table 1: Representation of Symptoms on Likert Scale.

Calculation of total mean score

After screening, sum of each symptom score was calculated for a total mean score. The respondents having a total score of 5 or above were categorized as SIBO suspected individuals [7] and were further selected for GBT.

Counseling of respondent for preparation of GBT

Suspected patients after initial screening were counseled before applying breath test [26] through phone calls and text messages for the preparation of GBT. Before breath test, participants were assured not to take any kind of antibiotic for 4 weeks prior to testing, do not eat any slowly digesting or fermentable foods like beans, soybeans, whole grain wheat products, oatmeal’s, lentils, and high

fiber cereals 24 hours before the testing, must have a fast for 12 hours and after overnight fast asked to rinse their mouth by any antiseptic mouthwash for at least 2 hours prior to testing in order to avoid false-positive test results by oral bacteria. They were asked not to smoke and sleep 2 hours before and during the testing.

Application of glucose H2 and CH4 breath test

The demographic data, family income, exercise, initiation of symptoms after food consumption and data for breath of selected participants were recorded before and after the administration of glucose (Figure b). The volunteers were administered with glucose solution, Sigma Aldrich, Darmstadt (Germany), (50g dissolved in 200mL mineral water) orally [27]. After administration, breath samples for H₂ and CH₄ were analyzed by chromatography using Quintron (Breath Analyzer, Model SC, Quintron Instrument Company, Milwaukee, Wisconsin, USA) after every 15 minutes for next 2 hours [7]. A mixture of H₂, CH₄, and CO₂ with a concentration of 150 ppm, 73 ppm, and 6.1% respectively were used as standard gases (Quintron) for calibration of equipment.

The form includes fields for ID, Profession, and Result. It contains several multiple-choice questions regarding family income, exercise habits, and symptoms after eating. A section for 'Starchy vegetables' lists options like Potatoes, Corn, Pumpkin, Beans, Lentils, Peas, and 'Any other'. Below the questions is a table for recording breath test results.

Sample	Clock Time	H ₂ (ppm)	CH ₄ (ppm)
Base Line			
After 15 min			
After 30 min			
After 45 min			
After 60 min			
After 75 min			
After 90 min			
After 105min			
After 120 min			

Figure b: Sample Taking Questionnaire.

Statistical analysis

A chi-square test was applied to develop a correlation of age, gender, and BMI with SIBO. P-value <0.05 considered as significant.

Simple frequencies were calculated to develop the association of SIBO with diet, exercise and exercise duration. Simple frequencies were also calculated to develop correlation with intensity, frequency and duration of signs and symptoms among SIBO positive individuals.

Results

The general distribution of population on the basis of gender, age, height, weight, and BMI who participated in the study is mentioned in table 2. Results showed that 14.02% of individuals were found suspected to have SIBO whereas, 85.96% of were found negative on the basis of score calculated through symptoms. GBT performed on the suspected population after the ingestion of glucose in fasting. Out of suspected population, 31.5% of individuals were found positive for SIBO and 68.5% were found negative or false positive as they showed symptoms close to positive. Furthermore, in the overall population tested 4.42% prevalence of SIBO was found.

Total Population (N): 385			
Grouping based on Gender			
Sr No.	Gender	Total individuals	Percentage
1	Male	49	12.73
2	Female	336	87.27
Grouping based on Age			
	Age (Year)	Total individuals	Percentage
1	< 20	30	7.79
2	20-30.9	335	87.01
3	31-40.9	13	3.38
4	41-50.9	4	1.04
5	> 50	4	1.04
Grouping based on height (cm)			
	Heights (cm)	Total individuals	Percentage
1	95-104.9	1	0.26
2	135-144.4	11	28.6
3	145-154.9	70	18.18
4	155-164.9	189	49.09
5	165-174.9	94	24.41
6	175-184.9	15	3.89
7	185-194.9	4	1.04
8	195-204.9	1	0.26

Grouping based on body weight				
	Body weight (kg)	Total individuals	Percentage	
1	30-40.9	18	4.67	
2	41-50.9	105	27.27	
3	51-60.9	132	34.28	
4	61-70.9	89	23.11	
5	71-80.9	25	6.49	
6	81-90.9	12	3.12	
7	91-100.9	3	0.79	
8	101-110.9	0	0.00	
9	111-120.9	1	0.26	
Grouping based on BMI (Kg/m ²)				
	BMI	Interpretation	Total individuals	Percentage
1	< 18.5	Under weight	77	20.00
2	18.5-24.9	Normal	234	60.78
3	25-29.9	Over weight	60	15.59
4	30-34.9	obese class 1	11	2.86
5	35-39.9	obese class 2	2	0.52
6	40 and above	obese class 3	1	0.26

Table 2: General Distribution of study participants.

Prevalence of SIBO in the study population

The present experiment also compared the efficiency of different types of breath tests based on hydrogen and methane. About 76.47% of individuals diagnosed with SIBO were positive for both H₂ and CH₄ tests. Whereas, 11.76% of total SIBO positive individuals were diagnosed on the basis of H₂ or CH₄ individually (Figure 1).

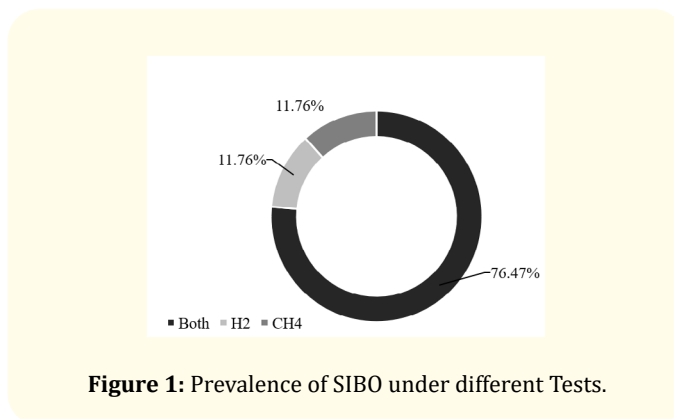


Figure 1: Prevalence of SIBO under different Tests.

Prevalence of SIBO and gender

A total 4.1% prevalence of SIBO was found among males and 4.5% of among females mentioned in table 3. Chi-square test of independence was calculated comparing the frequency of SIBO for males and females. No correlation was found between gender and SIBO ($p > .05$). Therefore, gender and SIBO appears to be independent events.

Condition	Male (%)	Female (%)
SIBO Negative	93.9%	95.5%
SIBO False Positive	2%	10.7%
SIBO Positive	4.1%	4.5%
Total participants	12.9%	87.3%

Table 3: Gender wise distribution of the screened population and its association with SIBO.

$p = .152$

Prevalence of SIBO in different Age Groups

When Prevalence of SIBO was found among different age groups, It has been found that 7% prevalence was found among age group <20 years of age where as 3.8% SIBO prevalence was found among the age group ranged from 20-30.9 years whereas no prevalence was found in later age groups (Figure 2).

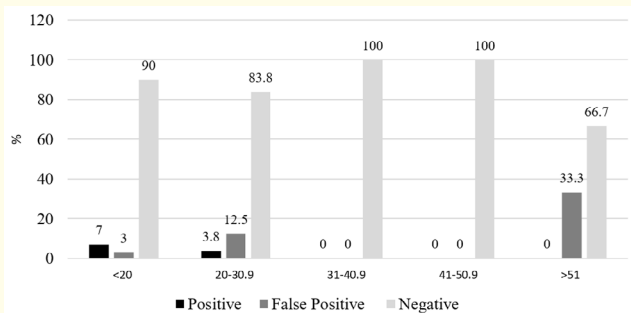


Figure 2: Prevalence of SIBO under different age groups and its association.

$p = .091$

(*) False Positive: Individuals suspected to have SIBO.

Prevalence of SIBO and BMI

3.9% SIBO prevalence was found among underweight, 5.1% among normal, 1.7% among overweight, and 9.1% in obese whereas no prevalence was found in later BMI groups. A non-significant relationship was found ($P = 0.965$). There was no correlation found between BMI and SIBO. Therefore, both are independent events (Figure 3).

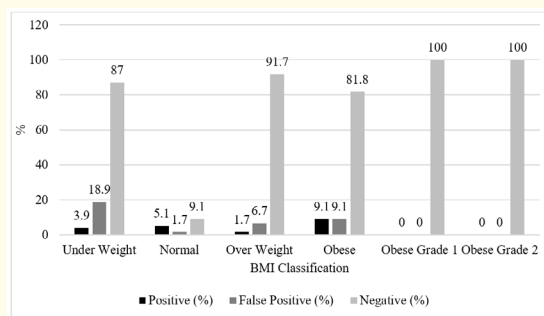


Figure 3: Prevalence of SIBO in different groups of BMI and its association.

$p = .965$.

Relationship of SIBO with food

In 88.2% SIBO positive individuals, symptoms initiate after eating specific foods while in 11.8% of individuals' symptoms were not correlated with specific foods mentioned in table 5. 70.6% SIBO positive individuals consumed starchy vegetables whereas 29.4% of SIBO positive individuals do not consume starchy food showing positive impact of starchy foods like potato, corn, pumpkins, beans, and lentils, etc. with SIBO.

Condition	Symptoms initiate after food (%)	Symptoms does not initiate after food (%)
SIBO Positive Individuals	88.2	11.8
Condition	Starchy vegetables Consumed (%)	Starchy vegetables Not consumed (%)
SIBO Positive Individuals	70.6	29.4

Table 4: Relationship of SIBO Positive Individuals with Food.

Condition	Relation of SIBO with Exercise		
	Performed exercise (%)	Do not performed exercise (%)	
SIBO positive individuals	35	65	
Duration of exercise	No exercise (%)	Less than 15 min (%)	More than 30 min (%)
SIBO positive individuals	64.70	29.40	5.90

Table 5: Relationship of SIBO Positive Individuals with Exercise.

Relationship of SIBO with exercise

Results showed that the prevalence of SIBO is high among individuals (65%) who do not perform an exercise as compared to those who performed an exercise (35%). Out of SIBO positive individuals who did not perform exercise often, duration to perform exercise has also been asked for further confirmation and results showed that 64.7% individuals did not perform exercise whereas 29.4% individuals performed an exercise for less than 15 minutes and only 5.9% individuals were positive for SIBO who performed an exercise for more than 30 minutes. It had been concluded that prolonging the duration of exercise reduces the SIBO prevalence.

SIBO prevalence in relation to different gastro-intestinal sign and symptoms

The results of the present experiment showed that the SIBO prevalence was associated with various gastrointestinal signs and symptoms. The signs and symptoms are common usually but SIBO positive patients have more chances to develop these signs and symptoms. The intensity, frequency, and duration of those signs and symptoms among SIBO positive individuals mentioned below.

Symptom 1: Abdominal pain, distention, cramps after eating something or having a meal

The results showed that 47.5% of the tested population felt abdominal pain, distention, and cramps after eating something or having a meal. The results also showed that 100% of the SIBO positive people showed signs of abdominal pain, distention and cramps before or after having a meal. Whereas 39.9% and 91.9% of SIBO negative and false positive population were positive for these signs and symptoms, respectively. The Chi-square test showed a significant relationship ($p < 0.05$). Intensity, Frequency and duration of abdominal pain, distention and cramps after eating something or having a meal were also monitored (Table 6).

Symptom/condition	Intensity (%)				Frequency (%)			Duration (%)				
	None	Mild	Moderate	Severe	None	<1/wk	1/wk	>1/wk	None	<10min	10-30 min	>30 min
Abdominal Pain	0	23.5	47	29.4	0	0	11.8	88.2	0	53	23.5	23.5
Belching	35.3	41.2	11.8	11.8	35.3	0	29.4	35.3	35.3	52.9	0	11.8
Bloating	0	35.3	23.5	41.2	0	0	23.5	76.5	0	41.2	11.8	47
Fullness	11.8	23.5	35.3	29.5	11.8	0	35.3	52.9	11.8	23.5	17.6	47.1
Indigestion	29.4	5.9	47.1	17.6	29.4	0	11.8	58.8	29.4	17.64	29.4	23.5
Nausea	17.6	11.8	41.2	29.4	17.6	0	29.4	32.2	17.7	17.7	47.1	17.7
Diarrhea	35.3	17.7	17.7	29.4	35.3	0	29.4	35.3	88.2	5.9	0	5.9
Vomitting	88.2	0	5.9	5.9	88.2	0	0	11,8	35.3	11.8	17,7	35.3
Gas trouble	23.5	5.9	47.1	23.5	23.5	0	23.5	53	23,5	23,5	17,7	35,3

Table 6: Intensity, Frequency and Duration of various symptoms/conditions among SIBO positive individuals.

Symptom 2: Belching before or after eating something or having a meal

The results of the present experiment showed SIBO positive individuals had a significantly higher percentage of belching. Among the tested population, 30.4% of individuals felt belching while a major share i.e. 69.60% of the population showed no belching. Similarly, SIBO positive people had more chances of feeling belching. The results showed 25.1%, 64.7% and 62.2% belching in SIBO negative, SIBO positive and SIBO false positive patients, respectively. Intensity, Frequency and duration of belching among SIBO positive individuals after eating something or having a meal were also be measured (Table 2).

Symptom 3: Bloating after eating something or having meal

The results showed that 50.1% of the tested population felt bloating (abdominal discomfort) after eating something or having meal. The results also showed that 100% of the SIBO positive people have reported that they felt bloating before or after having meal. Whereas 43.2% and 10.8% of SIBO negative and false positive population were also positive for this symptom, respectively. The Chi-square test showed a significant relationship ($p < 0.05$). Intensity, Frequency and duration of bloating after eating something or having a meal were also be measured among SIBO positive individuals (Table 6).

Symptom 4: Feeling of fullness before or after eating something or having a meal

The results of the present study showed that 51.9% of the tested population felt fullness before or after eating something or having meal. The results also showed that 88.2% of the SIBO positive people reported that they felt fullness before or after having meal. Whereas 48% and 70.3% of SIBO negative and false positive population were also positive for this symptom respectively. The Chi-square test showed a significant relationship ($p < 0.05$). Intensity, Frequency and duration of fullness after eating something or having a meal were also measured among SIBO positive individuals (Table 6).

Symptom 5: Feeling of indigestion before or after eating something or having a meal

The results of the present experiment showed significant differences among the individuals for the feeling of indigestion (dyspepsia-discomfort centred in the upper abdomen). In the overall population, a major share of individuals (61.5%) showed

no feeling of indigestion whereas the scenario is different in SIBO positive individuals; most of them (64.7%) responded they felt indigestion. Intensity, Frequency and duration of indigestion after eating something or having a meal were measured too (Table 6).

Symptom 6: Nausea before or after eating something or having a meal

The results of the current experiment showed significant differences among the individuals who felt nausea. Among the overall population, a major share i.e. 64.9%, reported no feeling of nausea or belching. Contrarily major share of SIBO positive individuals (82.4%) responded that they felt nausea before or after having a meal. Intensity, Frequency and duration of nausea after eating something or having a meal were measured also and shown the table 6.

Symptom 7: Diarrhoea

The results showed that 25.5% of the tested population had diarrhoea after eating something or having meal. While in SIBO positive individuals, 64.7% reported having diarrhoea. The Chi-square test showed a significant relationship ($p < 0.05$). Intensity, Frequency and duration of diarrhoea among SIBO positive individuals after eating something or having a meal showed in the table 6.

Symptom 8: Vomiting before or after eating something or having meal

The results of the present study revealed that only 7.3% of the tested population had vomiting before or after eating something or having meal. The results also showed that merely 11.8% of the SIBO positive people suffered from vomiting. Whereas 4.8% and 27% of SIBO negative and false positive populations found positive for this symptom respectively. Chi-square test of independence was calculated comparing the association of SIBO with vomiting before or after eating something or having meal. Significant relationship was found as $p = 0.000$. It showed SIBO and vomiting are not associated with each other. Intensity, Frequency and duration of vomiting among SIBO positive individuals were also measured (Table 6).

Symptom 9: Gas trouble before or after eating something or having meal

In this trial, 39% of the tested population felt gas trouble before or after eating something or having meal. In SIBO positive

individuals, 76.5% of respondents reported that they felt gas trouble before or after having meal. Whereas 31.7% and 86.5% of SIBO negative and false positive population were positive for these signs and symptoms, respectively. Chi-square test showed significant relationship ($p < 0.05$). Both are dependent events. Intensity, Frequency and duration of gas trouble after eating something or having a meal were measured too and depicted in table 6.

Discussion

The present study was the first of its kind in Pakistan aimed to investigate the prevalence of SIBO in the suspected individuals of Lahore and to develop an association of SIBO prevalence with age, gender, BMI, food and exercise. The suspected individuals identified were based on their feeling of abdominal pain, belching, bloating, fullness, indigestion, nausea, diarrhea, vomiting, and gas production. The technique used in this study was GBT which many studies have reported as an effective alternative to endoscopy [20].

In the specially designed questionnaire, the cut-off value for symptomatic questionnaire was 5 and above. Contrarily, Erdogan, *et al.* [7] used 6 as a cut-off point for SIBO suspected individuals with gastrointestinal symptoms as study participants in that trial were hospitalized whereas in current study participants were non-hospitalized. The results of screening showed a total of 14.02% suspected individuals (probability to have SIBO) in the overall population on the basis of mean score, as they had dominant GI symptoms. The present study showed that only GI signs and symptoms are not enough to diagnose SIBO and H_2 and CH_4 determination in breath is also necessary.

The results have reported a 4.42% prevalence of SIBO in population of Lahore while in suspected patients showing GI signs and symptoms, 31.5% prevalence of SIBO was observed. In accordance with findings of the present study, Lupascu, *et al.* [28] reported a 4% prevalence of SIBO in healthy individuals. Likewise, other studies reported 2.5% to 22% prevalence of SIBO [11,29]. Mac Mahon, *et al.* [1] reported 66.7% SIBO in patients with gastro intestinal symptoms. Another study conducted on healthy elders in the UK reported a 14.5% prevalence of SIBO [12]. The reason behind high prevalence in both previously mentioned was that they selected elder patients to assess SIBO whereas in the present study majority of the assessed population ranged from 20-39.9 years of age (Table

2). Dukowicz, *et al.* [13] reported 20% SIBO prevalence in healthy individuals without GI sign and symptoms. This high prevalence was due to using lactulose breath test whereas in the present study glucose hydrogen breath test was used to find out the prevalence of SIBO.

The study showed no association of SIBO with gender and reported a 4.5% prevalence of SIBO in females and 4.1% in males (Table 2). Accordingly, another study has also reported no association of SIBO with gender [30]. Whereas, Martins, *et al.* [31] revealed a higher prevalence of SIBO in females with intestinal symptoms. However, present study had also shown a relatively higher prevalence of SIBO in females (Table 2) but non-significant differences can be due to the use of healthy individuals for the preset experiment. Another reason behind the high prevalence of SIBO in females was their assessment of SIBO prevalence in irritable bowel syndrome (IBS) patients; IBS is more prevalent in females as compared to male i.e. 4:1 [32].

Result of the present research showed a non-significant association between age and SIBO (Figure 2). Only 7% prevalence of SIBO was observed in individuals less than 20 years and 3.8% prevalence was found in individuals 20 to 30.9 years old; whereas no prevalence of SIBO was found in individuals from 31 years old to above 50 years old.

The present study revealed that majority of SIBO positive individuals (88.2%) complained gastro intestinal sign and symptoms after consumption of food (Table 2). Probably availability of substrate and breakdown of indigested food by microbiota resulted in the production of gases and induction of GI sign and symptoms [33]. Similarly, Gabrielli, *et al.* [20] also reported that the majority of SIBO positive individuals complained initiation of GI symptoms after consumption of food.

Results of the present study also showed a higher prevalence of SIBO among individuals who consumed starchy food items like potatoes, pumpkins, corn, beans and lentils. As wheat is the staple food of Pakistan, majority of population i.e. 60-74% consume carbohydrate-containing starchy foods which showed they are at increased risk to develop SIBO. Moreover, it can be deduced that those who's staple food is carbohydrate- containing foods, they are at higher risk to develop SIBO [34]. Other studies have also reported an increase in the prevalence of SIBO in patients consuming

fibrous diet [35]. The increase could be due to presence of glucides in starchy food which is a readily available food for gut microbiota [33]. Moreover activity of brush border disaccharidases also reduced due to which malabsorption of saccharides (starchy food) occurs [36]. In accordance, de Roest, *et al.* [37] reported that SIBO symptoms were reduced in 75.6% cases by giving low fermentable oligo-, di-, and monosaccharides and polyols, they are also called as FODMAPS diet.

The present study showed that a low prevalence of SIBO (35%) was found among individuals who performed exercise usually whereas high prevalence (65%) was found among those who didn't perform an exercise. In accordance, Kang, *et al.* [38] reported that exercise improved the composition of gut microbiota and also improved the amount of beneficial bacteria like *Lact. rhamnosus* and Bacteroidetes to Firmicutes ratio. Similarly, another study had also reported that exercise made changes in microbiota and reduce some specific bacteria like Tenericutes which were directly linked with diseases. Moreover, exercise also reduced Lachnospiraceae and Ruminococceae which were directly associated with anxiety and depression [39].

Abdominal pain, belching, bloating, fullness, indigestion, nausea, diarrhea and gas production showed a strong association with SIBO while no association was observed for vomiting. In accordance with present study findings, another study had reported that the individuals positive for SIBO frequently had gastrointestinal symptoms as compared to individuals who showed negative results for SIBO [31]. Similarly, according to another study it had been reported that bloating, fullness, abdominal pain, and gas production were the dominant symptoms in patients having 6 and above mean score [7].

Conclusion

Based on the results of present study it can be concluded that a considerable population of Lahore is affected by SIBO and probability is much higher among individuals with GI signs and symptoms. There is no association of SIBO with age, gender, and BMI but the prevalence is relatively higher in females, individuals with age less than 20 years, and obese people according to the results of present study. The consumption of starchy foods and absence of exercise in daily routine also results in higher prevalence of SIBO. Individuals who performed exercise for more than 30 minutes have

a minimum prevalence of SIBO. Furthermore, GI signs and symptoms are not enough to diagnose SIBO but both H₂ and CH₄ should be used for diagnosis.

Limitations

Limitations of the study were that majority of the study participants were female and lied in the age 20-30.9 years of age. Therefore, there was not equal distribution of participants according to gender and age groups.

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Conflict of Interest

It is to declare that authors do not have any kind of conflict of interest for publishing this article.

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