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INVESTIGATING THE RELATIONSHIP BETWEEN POST-MEAL FLUID INTAKE, ABDOMINAL OBESITY AND GUT HEALTH

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Abstract

Fluids are necessary for life, but their role in gut health promotion is not fully known. It is essential to drink water at the proper times to avoid numerous digestive illnesses. Gut health includes the gastrointestinal (GI) tract, food digestion, absorption, sickness, and immunity. Gastroesophageal reflux disease (GERD) is a medical illness characterized by symptoms such as acid reflux and heartburn. Abdominal obesity is sometimes connected with poor hydration intake and GI tract issues. In 2016, 1.9 billion individuals were reported to be overweight globally, with 650 million classified as obese. Water consumption is rarely documented in dietary surveys. The current study aimed to assess the pattern and frequency of post-meal fluid consumption, as well as the potential relationship among gut health, abdominal obesity, along with fluid consumption patterns. It was a survey-based study in which 268 persons were randomly selected to complete a food frequency questionnaire (FFQ). A web-based survey was used to collect information about eating habits, fluid intake, anthropometric measures, and lifestyle. The data was examined using SPSS software to determine the level of significance. The frequency distribution was verified, and chi-square tests were run on the data. The findings demonstrated a strong correlation between intestinal health, abdominal obesity, and post-meal fluid intake. Obesity was shown to be significantly associated with intra-

meal fluid intake. There was also a considerable correlation between the intake of sugar-sweetened drinks. To have a better knowledge of the relationship between dietary habits, obesity, and gut health, further research is encouraged.

Key words: Abdominal obesity, gut health, fluid intake, GERD, GI tract

1. Introduction:

The impact of various beverages on health is a growing field of study, as the human body requires 60% water for survival 1.Drinking water after eating is crucial to prevent gastrointestinal infections caused by microorganisms, and the best time to do so is after some time has passed since eating [2]. Dietary surveys often lack information on water intake and hydration status. Drinking 500 mL water before meals can reduce postprandial hypotension. Meal-related factors, including water availability, moderate portion size and can help alleviate obesity by promoting gastrointestinal microbiome composition [3, 4, 5, 6].

Gut health refers to positive gastrointestinal tract characteristics such as successful food absorption and digestion, elimination of gastrointestinal illness, a healthy intestinal microbiome, a functional immune system, and well-being. Diet is the primary factor in forming the gut microbiota. Dysbiosis, or altered gut bacterial composition, can lead to inflammatory infections and diseases [7]. Postprandial distress syndrome (PDS) and epigastric pain symptoms are symptoms of functional dyspepsia and unexplained epigastric pain [8].

Irritable bowel syndrome (IBS) is a persistent abdominal pain with irregular movements, linked to a healthy lifestyle, with symptoms including constipation, diarrhea, and mixed stools [9, 10, 11]. Obesity is a global health issue, with 107.7 million obese children and 603.7 million obese adults in 2015. In 2016, there were over 1.9 billion overweight or obese adults worldwide, with over 650 million being obese. In Pakistan, 22.8% of participants were overweight, while in the US, 39.8% are obese [12, 13]. Abdominal obesity and excessive sugar-sweetened beverages are linked to various ailments, including diabetes mellitus. Abnormal adiposity increases inflammation in the liver, leading to increased prevalence of non- communicable diseases [14]. Lifestyle factors, genetics, and environmental influences also impact body composition [15]. Metabolic disorders like obesity, diabetes, osteoporosis, and metabolic syndrome (MetS) are prevalent and challenging to treat due to sedentary lifestyles, inadequate diets, and lack of physical activity [16].

Pakistan faces over-nutrition and under-nutrition challenges, with 8.1% of adolescents aged 5-17 obese and 17% overweight, according to the 2017-18 National Health Survey [17]. The gut, a vital part of the digestive system, plays a significant role in gut health, encompassing the human gut microbiome. Upper gastrointestinal symptoms (UGIS) can be a significant economic burden, affecting healthcare costs [18]. Obese children have distinct gut microbiota compared to healthy ones, providing a foundation for obesity treatment. Research links gut microbiota and weight gain, and obesity severity worsens dehydration in children [19, 20].

Low potassium intake and excessive sodium consumption are significant predictors of dehydration. The presence of liquid in food can alter solid food emptying patterns, and drinking water, a vital fluid source, has been overlooked in human microbiome research [11, 21]. High-calorie meals cause endothelial dysfunction, while antioxidant-rich beverages protect against this [22]. Overweight and obesity are major health issues, with body weight growth influenced by positive energy balances. Despite increased physical activity, diet-related disorders continue to rise despite dietary recommendations [23]. Up to 20% of Western individuals suffer from upper gastrointestinal diseases, with functional dyspepsia and gastroesophageal reflux disease being the most common. The cause of these diseases is unclear, and medical treatments often fail, leading to high costs and patient suffering [24]. The study aimed to understand dietary habits, water consumption patterns, and lifestyle choices affecting gut health. A validated self-administered questionnaire measured

waist circumference, height, and weigh. This study looked at the frequency and pattern of post-meal fluid intake, as well as the link between fluid consumption, abdominal obesity, and gastrointestinal health.

2. MATERIALS AND METHODS

2.1. Study plan and data collection

A cross-sectional survey study was conducted among 268 Pakistani adults aged over 18 years, using convenience sampling from urban and rural areas. Data was collected through a web survey using a food frequency questionnaire (FFQ). The sample size was calculated based on a 95% confidence interval and a 5% margin of error. Abdominal obesity was defined as waist circumference of more than 88 cm for women and 102 cm for men, while general obesity was defined as BMI of 30 kg/m2. Participants were asked for informed consent and kept anonymous. The study used a self-administered questionnaire to gather data on participants' socioeconomic status, demographics, eating habits, and anthropometric measurements. The questionnaire, which was structured from March 2023 to April 2023, included questions on demographics, medical history, dietary habits, and fluid intake patterns.

Individuals inclusion and exclusion criteria

This study included subjects over 15 years old, including those who consumed water, milk, fruit juice, milk-tea, and sweetened beverages, as these drinks are popular and affect population health. This study excluded individuals with a history of disease, those taking medications, pregnant or lactating women, and those under 15 years old.

2.2 Questionnaire design

A standardized, structured qualitative questionnaire for a survey-based study was developed by reflecting on previous research and organizations, considering content, response burden, and practical factors. The research paper developed a questionnaire that met the research requirements. A pre-test was conducted to assess respondents' interpretation and response. A pilot test evaluated the questionnaire's validity and readability. The final survey was tested on ten randomly selected respondents, adjusted to fit society, and obtained consent from the relevant supervisor before launch.

2.3. Structure of the questionnaire

The questionnaire collected information on IBS, fluid intake, obesity, and intestinal health, using closed-ended questions, multiple-choice and dichotomous options, and categorizing demographics, medical history, gut health, and fluid intake. The detailed self-structured questionnaire that was used for data collection and consists of the following parts:

a) Demographic data

It includes questions about age, gender, smoking status, medical history, social status, and chronic disease history.

b) Anthropometric measurements

The anthropometric measures included questions on weight, height, and BMI. Participants' weight was measured using an analogue scale, and their BMI was calculated using a manual conversion from centimeters to meters. The study categorizes participants as underweight, normal weight, prone to overweight, and obese. The height was measured without shoes using a calibrated wall-mounted stadiometer. Participants stood straight with their shoulders, buttocks, and heels in contact with the wall, wearing only their heads and feet. Height was measured to the nearest 0.1 cm. The BMI metric formula, weight in (kg)/height in (m2), was used to calculate body mass index (BMI) and evaluate nutritional status, categorizing individuals as underweight, normal weight, overweight, or obese, in

accordance with WHO standards. Lin 14 propose waist circumference as a more effective, less complicated, and affordable alternative to BMI for detecting abdominal obesity.

c) Assessment of dietary habits

Individuals' dietary habits were assessed through various domains, including meal frequency, meal patterns, intra-meal fluid intake, pre-meal and post-meal fluid intake, and the interval of food and water intake after a meal.

d) Evaluation of eating patterns

The study examines people's dietary habits by analyzing their daily meal frequency, eating patterns, fluid intake, fast food consumption, and outdoor meals, gathering detailed information on each domain to understand their eating habits.

e) Assessment and evaluation of physical activity

The study assessed a person's lifestyle by examining their level of physical activity. It classified them as sedentary, active, or very active, with sedentary being basic, active being moderate, and very active being strenuous. Participants were given options for time and intensity of physical activity.

2.3. Data analysis

The study analyzed data on lifestyle, nutritional, and bowel health indicators, including fiber intake, using SPSS software. The Chi-square test assessed relevance of post-meal fluid intake, abdominal obesity, and gut health 25. Descriptive statistics summarized demographic and clinical characteristics. Primary outcome variables were abdominal obesity and gut microbiome diversity, while post-meal fluid intake was the independent variable. Linear regression models examined the relationship between these variables.

2.4. Ethical considerations

The University of Agriculture Faisalabad approved the study, obtained informed consent from all participants, and ensured confidentiality throughout.

3. RESULTS

3.1 Frequency distribution on basis of medical history and general differences among different individuals

Table 4.1 displays the gender, age and BMI distribution of 268 individuals, categorized as "Male" and "Female." The data shows women are more likely to be represented, with 80 males making up 29.9% of the sample, and 188 females, with a gender identification rate of almost 70.1%. The data is categorized into four age groups: 15-25, 26-35, 36-45, and > 45. The data is categorized into four groups: "Underweight," "Normal," "Overweight," and "Obese," with 25 individuals, or 9.3%, classified as underweight. The respondents' average BMI value of 2.49 indicates a relatively low BMI, with interpretation varying based on measurement units like kg/m^2 or lbs/in^2. Table 1 shows 268 people with a 100% cumulative percentage, with rounding possibly causing a small difference. It provides an overview of educational levels, including Bachelors, Masters, PhDs, and those below Bachelors.

Table 1. Frequency distribution of BMI, age and gender of individuals under study

Criteria	Subject	Frequency	Percent (%)
Gender	**Male**	80	29.9
	Female	188	70.1
Age	**15-25**	195	72.8
	26-35	56	20.9

	36-45	13	4.9
	> 45	4	1.5
BMI	**Underweight**	25	9.3
	Normal	116	43.3
	Overweight	97	36.2
	Obese	30	11.2
Education level	**Bachelors**	115	42.9
	Masters	114	42.5
	PhD	15	5.6
	Less than Bachelors	24	9

Figure 1 shows the distribution of people in a sample based on their medical status, with 17.9% having a medical problem and 82.1% not. The information is divided into "Yes" and "No" categories, with "1" indicating the presence of a condition and "2" indicating the absence. A total of 134 individuals, or 50.0% of the sample, reported stomach or digestive issues, with half reporting none, indicating an evenly split distribution in the sample. 41.4% of individuals recently gained weight, while 58.6% did not, indicating a significant portion of the population has experienced weight gain. A sample of 93 people reported gaining weight around their waists, while 65.3% of the total did not, indicating a significant weight increase in the area. The study found that 24.6% of the participants experienced stress due to weight gain, while 75.4% did not feel stressed due to weight gain. The study found that a majority of individuals (74.3%) drink water before a meal, while a smaller proportion (25.7%) do not. Between meals, 75.7% of the population drinks water, while 24.3% do not. After meals, 57.1% of the population drinks water, while 42.9% do not. The majority of individuals do not drink water after a meal. The data suggests that hydration is crucial for overall health. The study found that 58.4% of the sample felt bloated, while 42.2% did not, and 59.7% felt gassy. The remaining 40.3% did not feel gassy, with a total of 155 individuals reporting bloating, 113 not feeling bloated, and 108 not feeling gassy.

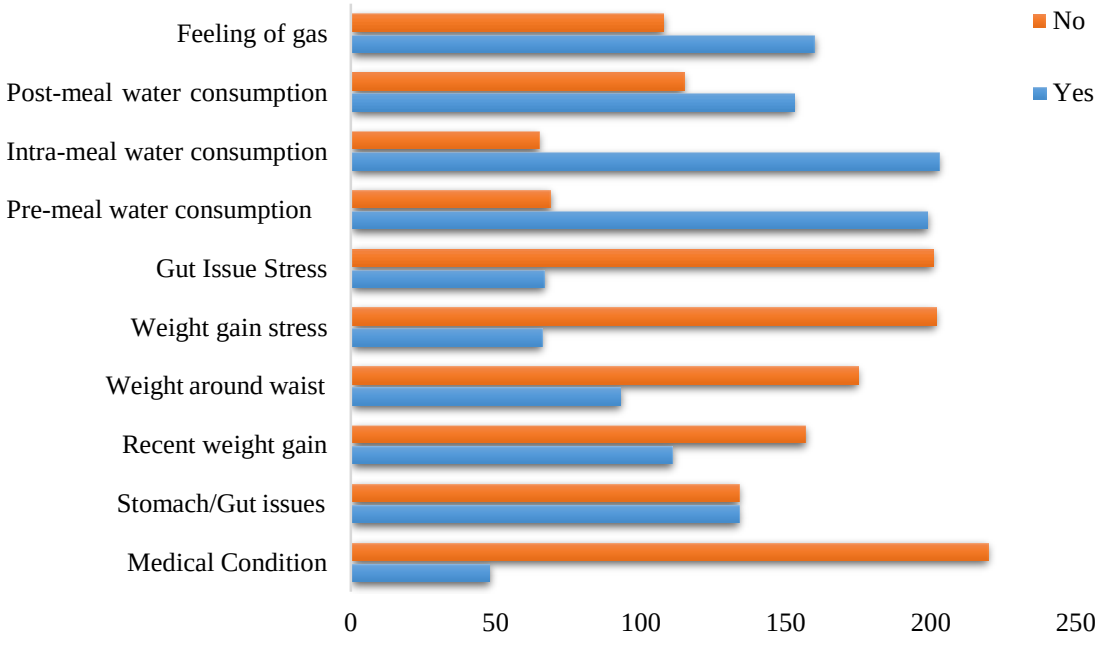

Figure 1. Frequency distribution of various medical issues related to obesity/weight gain

3.2. Chi-square analysis of different frequency distributions

The study found a significant association between gender and the prevalence of medical conditions, with a p-value of 0.028 and a Chi-square value of 4.85. However, more information on specific conditions and their distribution among genders is needed for a comprehensive interpretation. A significant association was found between gender and the prevalence of gut diseases such as diarrhea, constipation, irritable bowel syndrome, and lactose intolerance. Table 2 indicates different parameters that are linked together with the health and well being of an individual. The p-value of 0.014, which is below the 0.05 threshold, indicates a significant relationship between gender and the prevalence of these conditions. The Chi-square value 12.51 indicates that gender may play a role in the occurrence of these conditions. However, further investigation is needed to understand the nature of this relationship and identify potential underlying factors.

Table 2. P value and Chi-square values for different parameters under study

Variable	P value	Chi-Square
Medical condition	0.028*	4.85
Gut Diseases	0.014*	12.51
Emotional well-being	0.000**	18.76
Medical Condition	0.000**	19.04
Post meal water intake	0.044*	8.09
Feeling of fullness	0.007**	12.08
Post meal water intake	0.06 ^{NS}	7.22
Feeling of nausea	0.017*	10.23
Irritation in oesophagus	0.05*	7.76
General perception	0.57 ^{NS}	1.99
General perception intra meal	0.05*	7.44

*Significant ≤ 0.05, **Highly Significant ≤ 0.001 ,^{NS} Non-Significant > 0.05

The study indicates a significant correlation between body mass index (BMI) and nausea post-meal water intake in the sample population. A strong association between gender and emotional well-being, with a p-value of 0.000 was observed. The analysis revealed a strong association between age and medical condition prevalence with a Chi-square value of 19.04, suggesting age may be a determining factor.

3.3 Cross-tab analysis for post-meal fluid intake with prevalence of gut issues and obesity

The statistical analysis reveals a significant relationship between "Feeling of gas" and "Post meal fluid intake," with a p-value of 0.009 indicating a probability of less than 0.01 and a Chi-square value of 6.773, indicating a discrepancy between observed and expected frequencies under the null hypothesis. The study found a strong association between feeling of nausea and the factor of heart burn/GERD, with a p-value of 0.000 and a Chi-square value of 24.276. This indicates a low probability of obtaining the observed association by chance alone. The Chi-square value of 22.400 measures the discrepancy between observed frequencies and expected frequencies under the null hypothesis. The p-value of 0.000 is considered highly significant at a conventional significance level of lower than 0.01.

Table 2. P value and Chi-square values for different parameters under study

Variable	P value	Chi-Square
Feeling of gas	0.009**	6.773
Feeling of nausea	0.000***	24.276
Feeling of Heart burn	0.000***	22.4
Irritation in oesophagus	0.001***	11.215
Constipation	0.001***	11.25
BMI/Obesity	0.055*	7.227

*Significant ≤ 0.05, ** Very Significant ≤ 0.01, ***Highly Significant ≤ 0.001

Thus, the findings suggest a strong association between heartburn and GERD in individuals who consume water after meals. The p-value of 0.001 and Chi-square value of 11.215 indicate a significant difference in the observed distribution of responses for "Irritation in esophagus" at a conventional significance level of 0.05. The p-value of 0.001 indicates a low probability of obtaining the observed association between variables, while the Chi-square value of 11.250 indicates a significant difference in the observed distribution of responses for "Constipation." The p-value of 0.055 indicates a low probability of a significant association between BMI/Obesity and the variable, but above the 0.05 level. The Chi-square value of 7.227 indicates a moderate difference between the observed and expected frequencies, indicating a moderate difference in the distribution of responses for the variable. Cross-tabs show a strong correlation between post-meal fluid/water intake and gut and stomach issues, and a reasonable relationship between water intake and obesity.

Table 3. Cross-tabs for post-meal fluid intake with prevalence of gut issues and obesity

Cross-tab	Q1	"Do you drink water after meal?"		Total
		Yes	No	
Q2. "Do you feel gassy?"	**Yes**	81	72	153
	No	79	36	115
Q3. "Do you drink water after meal?"	**Yes**	44	109	153
	No	67	48	115
Q4. "Do you feel heartburn/ acid reflux?"	**Yes**	61	92	153
	No	79	36	115
Q5. "Do you feel irritation in your throat/oesophagus?"	**Yes**	56	98	154
	No	64	50	114
Q6. "Do you experience constipation?"	**Yes**	65	87	152
	No	73	42	116
Q7. Level of obesity BMI(kg/m^2).	**Underweight**	17	8	25
	Normal	69	47	116
	Over weight	46	51	97
	Obese	21	9	30

4. Discussion

As explained by 10, constipation, diarrhea, or mixed stools are the three subtypes of IBS. According to Sirasa 26, a lot of factors like nutritious diet, diet diversity and, habits play an important role in determining the well-being of a person. So it is important to consider other variables and potential confounding factors that may influence emotional well-being. As mentioned by Vieux 27, in the study where age groups were formed to check the water consumption patterns for determining various factors. It is worth noting that the statistical significance of this analysis indicates that age is a significant factor in the prevalence of medical conditions within the given sample. Due to insufficient fluid intake, low-intake dehydration affects elderly people frequently Jimoh 28. That explains the difference in hydration status according to age. In conclusion, the analysis indicates that there is a significant association between age and post-meal water intake. Results of a study by Carroll 29 showed that acute changes in hydration status impacted cravings. However, it is crucial to

interpret these findings with caution and consider other potential factors that may contribute to this relationship 30. Postprandial distress syndrome can cause bothersome early satiety, post-meal fullness, belching, and nausea 8. The study performed by Zaribaf 31 found a significant link between IBS and excessive intra-meal fluid intake. Diet is believed to play a major role in determining the gut microbiota throughout the course of a lifetime and is causative for various gut issues 7. The prevalence of acid reflux in a study is found to be much higher in obese and overweight students, indicating that obesity has a big impact on GERD 32. According to Raczkowska 15 shift in body composition results from abnormal energy balance. There is a correlation between lifestyle factors including food and steroid use, as well as hereditary and environmental factors. The percentage of persons in each activity group, ranging from low activity to sedentary and very active, depending on their self-rated level of activity within the sample are presented 33. When dietary deficiencies, sedentary jobs, and a lack of physical activity disrupt physiological metabolic pathways, metabolic disorders begin to manifest 16. It has been proposed that a primary management strategy for digestive problems is to establish a healthy living pattern and refrain from experiencing psychological distress 9. In a survey study that was conducted in six countries, three different habits of drinking fluids were found, including drinking with meals, drinking alone, and a type of 'grazing' behavior that involves having many drinks throughout the day. Most drinking events took place at home 34. Most students drink 5-7 glasses of water each day, but young people only take 2-4 glasses daily, according to a poll. These findings strongly imply that the kids are ignorant of the problems caused by drinking less water 33. According to Kanmani 35 drinking water prior to meals can help overweight women lose weight and enhance their quality of life. The association between fluid intake during meals and overall abdominal obesity was investigated by Salari-Moghaddam 12 in a survey study that presented a significant relationship. Among research participants, there is a lot of variance in ingestive behavior 36. The optimum times for fluid intake are after a while has elapsed since eating, not while or immediately after eating. Person who drink water an hour after eating rather than immediately before are less likely to contract germs 2. The prevalence of acid reflux in a study is found to be much higher in obese and overweight students, indicating association between obesity and GERD 32. Upper gastrointestinal problems are typically present in the general population 18. A majority of people out of the population sample did not experienced constipation after drinking fluids after meals. These findings suggest a strong association between experiencing constipation and consumption of water after meals 37. The optimal times to drink fluids are not while or immediately after eating, but rather after a while has passed 2.

5. Conclusion

This study evaluated post-meal fluid consumption patterns and potential associations between gut health, abdominal obesity, and fluid consumption patterns, using a food frequency questionnaire, to understand the role of fluids in gut health promotion. This study aimed to explore the relationship between post-meal fluid intake, abdominal obesity, and gut health in a Pakistani population. The study used body composition analysis, gut microbiome analysis, and dietary assessment to examine the potential associations. The majority of participants, 128 or 47.8%, reported no disorders or symptoms. The second most common condition was constipation, reported by 64 or 23.9% of the sample. Diarrhea was reported by 24 or 9.0% of the total. Irritable bowel syndrome was claimed by 25 or 9.3% of the sample. Lactose intolerance was cited by seven people, accounting for 2.6% of the total. 199 people reported drinking water before a meal, accounting for 74.3% of the total. The majority of people, 74.3%, reported drinking water before a meal, while a lesser minority, 25.7%, did not. 203 people reported drinking water between meals, accounting for 75.7% of the total. Lastly, 65 people, or 24.3%, reported not drinking water between meals. The study found a strong relationship between post-meal fluid intake and gut issues and BMI in Pakistan. 153 individuals reported drinking water after a meal, while 42.9% did not. The findings could help prevent obesity and manage metabolic disorders in Pakistan, and contribute to understanding the role of post-meal fluid intake in abdominal obesity. The relationship between education levels and intra-meal fluid

intake perceptions is complex and requires further research. Factors like cultural beliefs and practices, as well as specific categories of education, may also influence this relationship. Further research, including qualitative surveys and additional variables, is recommended for a more comprehensive understanding.

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REFERENCES

1. Daniels MC, Popkin BM. Impact of water intake on energy intake and weight status: A systematic review. Nutr. Rev. 2010;68(9):505-21.
2. Parajuli KP, Chaulagain DD, Singh G, Shrestha M. The microbial invasion of gastro intestianal tract and habit of drinking water immediately after meals. J. Nobel Med. Coll. 2014;3(1):58-61.
3. Gibson S, Gunn P, Maughan R. Hydration, water intake and beverage consumption habits among adults. Nutr. Bull. 2012;37(3):182-92.
4. Grobéty B, Grasser EK, Yepuri G, et al. Postprandial hypotension in older adults: Can it be prevented by drinking water before the meal? Clin. Nutr. 2015;34(5):885-91.
5. Cunningham PM, Roe LS, Keller KL, Rolls BJ. Switching between bites of food and sips of water is related to food intake across meals varying in portion size. Appetite. 2023;182:106443.
6. Kim B, Choi H-N, Yim J-E. Effect of diet on the gut microbiota associated with obesity. J. Obes. Metab. Syndr. 2019;28(4):216.
7. Thursby E, Juge N. Introduction to the human gut microbiota. Biochem. J. 2017;474(11):1823-36.
8. Koch KL, Van Natta M, Parkman HP, et al. Effect of liquid and solid test meals on symptoms and gastric myoelectrical activity in patients with gastroparesis and functional dyspepsia. Neurogastroenterol. Motil. 2023;35(2):e14376.
9. Hajishafiee M, Keshteli AH, Saneei P, et al. Healthy lifestyle score and irritable bowel syndrome: A cross-sectional study in adults. Neurogastroenterol. Motil. 2020;32(5):e13793.
10. Waldman SA, Tenenbaum R, Foehl HC, et al. Blunted evoked prouroguanylin endocrine secretion in chronic constipation. Clin. Transl. Gastroenterol. 2019;10(7).
11. Vanhaecke T, Bretin O, Poirel M, Tap J. Drinking water source and intake are associated with distinct gut microbiota signatures in US and UK populations. J. Nutr.2022;152(1):171-82.
12. Salari-Moghaddam A, Aslani N, Saneei P, et al. Water intake and intra-meal fluid consumption in relation to general and abdominal obesity of Iranian adults. Nutr. J. 2020;19:1-8.
13. Gelberg L, Rico MW, Herman DR, et al. Comparative effectiveness trial comparing myplate to calorie counting for mostly low-income Latino primary care patients of a federally qualified community health center: study design, baseline characteristics. 2019;19(1):1-21.
14. Lin W-T, Kao Y-H, Li MS, et al. Sugar-sweetened beverages intake, abdominal obesity, and inflammation among us adults without and with prediabetes-an NHANES study. Int. J. Environ. Res. Public Health. 2022;20(1):681.
15. Raczkowska E, Bienkiewicz M, Gajda R, et al. Do body composition and values of selected nutritional status indices influence the glycaemic index values of vegetarian dishes? A pilot study in a group of older women. Int. J. Environ. Res. Public. Health. 2022;19(16):9918.
16. Bourebaba Y, Marycz K, Mularczyk M, Bourebaba L. Postbiotics as potential new therapeutic agents for metabolic disorders management. Biomed. Pharmacother. 2022;153:113138.
17. Irfan S. Frequency and risk factors of overweight and obese school going adolescents of district Peshawar, Khyber Pakhtunkhwa, Pakistan. J. Med. Sci. 2022;30(01):62-7.
18. Haycox TE, A. Eggleston, A. The health economic impact of upper gastrointestinal symptoms in the general population: Results from the Domestic/international gastroenterology surveillance study (DIGEST). Scand. J. Gastroenterol. Suppl. 1999;34(231):38-47.
19. Hou Y-P, He Q-Q, Ouyang H-M, et al. Human gut microbiota associated with obesity in chinese children and adolescents. Biomed Res. Int. 2017:2017.

20. Kozioł-Kozakowska A, Wójcik M, Stochel-Gaudyn A, et al. The severity of obesity promotes greater dehydration in children: preliminary results. Nutrients. 2022;14(23):5150.
21. Kim J, Oh S-W, Myung S-K, et al. Association between coffee intake and gastroesophageal reflux disease: A meta-analysis. Dis. Esophagus. 2014;27(4):311-7.
22. Muggeridge DJ, Goszcz K, Treweeke A, et al. Co-ingestion of antioxidant drinks with an unhealthy challenge meal fails to prevent post-prandial endothelial dysfunction: an open-label, crossover study in older overweight volunteers. Front. Physiol. 2019;10:1293.
23. Ahmed HO, Marif MAH, Omer MAA, et al. The life styles causing overweight or obesity: Based on 5 years of experience in two centers in sulaimani governorate, Kurdistan region/Iraq. Int. J. Surg. Open. 2018;11:22-29.
24. Storlid E, Hausken T, Lied G, et al. Gastric accommodation in healthy subjects studied by ultrasound, manometry, and impedancemetry. Neurogastroenterol. Motil. 2018;30(4):e13249.
25. Montgomery DC. Design and analysis of experiments: John wiley & sons; 2017.
26. Sirasa F, Mitchell L, Harris N.Dietary diversity anf food intake of urban preschool children in north-western Sri Lanka. Matern. Child Nutr. 2020;16(4):e13006.
27. Vieux F, Maillot M, Rehm CD, et al. The timing of water and beverage consumption during the day among children and adults in the united states: Analyses of NHANES 2011-2016 data. Nutrients. 2019;11(11):2707.
28. Jimoh OF, Brown TJ, Bunn D, Hooper L. Beverage intake and drinking patterns—clues to support older people living in long-term care to drink well: DRIE and FISE studies. Nutrients. 2019;11(2):447.
29. Carroll HA, Templeman I, Chen Y-C, et al. Hydration status affects thirst and salt preference but not energy intake or postprandial ghrelin in healthy adults: A randomised crossover trial. Physiol. Behav. 2019;212:112725.
30. Brockman TA, Sim LA, Biggs BK, Bronars CA, et al. Healthy eating in a boys & girls club afterschool programme: Barriers, facilitators and opportunities. Health Educ. J. 2020;79(8):914-31.
31. Zaribaf F, Keshteli AH, Esmaillzadeh A, et al. Empirically derived dietary habits are associated with irritable bowel syndrome. Eur. J. Clin. Nutr. 2018;72(11):1537-47.
32. Elnemr GMH, Almuntashiri AH, Alghamdi SA, et al. The predictors of gastroesophageal reflux disease among university students: A cross sectional study in the western region of Saudi Arabia. Egypt. J. Hosp. Med. 2018;73(1):5828-38.
33. Al-Dayan, N. Association between dietary patterns and chronic disease among female students, prince sattam university, Al-kharj, Saudi Arabia. Prog. Nutr. 2021;23(4).
34. Morin C, Gandy J, Moreno L, et al. A comparison of drinking behavior using a harmonized methodology (Liq.In 7) in six countries. Eur. J. Nutr. 57:101-112.
35. Kanmani MK, Abirami P, Kanniammal C. A study to assess the effectiveness of premeal consumption of water on quality of life and body weight among women with over weight in selected villages, at kattankulathur block. J. Pharm. Negat. Results. 2022:3439-44.
36. Serra M, File B, Alceste D, et al. Burst-pause criterion derivation for drinkometer measurements of ingestive behavior. MethodsX. 2022;9:101726.
37. Gow ML, Pham-Short A, Jebeile H, et al. Current perspectives on the role of very-low-energy diets in the treatment of obesity and type 2 diabetes in youth. Diabetes, Metab. Syndr. Obes. 2021:215-25.