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Research Article

Abdominal Pain and High FODMAP Meals in School children

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Abstract

Fermentable oligosaccharides, disaccharides, monosaccharides and polyols (FODMAP) are thought to cause abdominal pain (AP) in children. No studies have investigated whether the FODMAP content of school lunches could be associated with AP in otherwise healthy children attending school. The primary aim of the study was to assess the relationship between FODMAP load, portion sizes consumed and AP in a sample of schoolchildren. In this prospective school-based study, children received a meal with varying FODMAP loads at lunchtime. Participants completed standardized questionnaires and reported presence and severity of AP on a numeric rating scale (0-10). We found no significant association between the FODMAP load and development of AP ($p = 0.2808$) or severity of AP ($p = 0.1865$). Children that reported AP following the meal ate a smaller portion size (73.6%, SD = 0.25) than children who did not report AP (85.4%, SD = 0.20) regardless of FODMAP content. To summarize, AP is highly prevalent in schoolchildren in Argentina. Children did not develop more frequent or severe AP with increasing FODMAP loads.

Keywords: *Children; FODMAP; Abdominal Pain; Gastrointestinal; Irritable Bowel Syndrome; DGBI*

Introduction

Seventeen percent of schoolchildren in Argentina have a disorder of gut-brain interaction (DGBI) [1]. In a prospective school-based study, more than half of children reported abdominal pain (AP) at least once, with a weekly prevalence of 38% [2]. In contrast to adults, AP in children is more prevalent during winter than summer months [3]. The cause of the winter predominance of AP in children remains unclear. Although some studies attribute this phenomenon to school related stress, other studies have not found an association between AP and school stressors [4]. Other factors such as the child's inability to play outside during colder months, the densely populated school environment that make children more susceptible to acquire infections, and diet have also been considered as potential contributors of the winter predominance of AP [3].

Fermentable oligosaccharides, disaccharides, monosaccharides and polyols (FODMAP) are thought to cause AP in children, particularly those with functional abdominal pain [5]. FODMAP are poorly absorbed and osmotically active short-chain carbohydrates. Once passed

into the colon, fermentation is initiated by bacteria resulting in the production of hydrogen and methane. This process is theorized to induce gastrointestinal symptoms particularly in those with visceral hypersensitivity [6,7]. Most children with irritable bowel syndrome report dietary intolerances [8]. Studies have found that the ingestion of FODMAP can trigger AP in pediatric and adult patients with irritable bowel syndrome [9] and that limiting the FODMAP load can improve symptoms [10]. No studies have investigated whether the FODMAP content of school lunches could be associated with AP in otherwise healthy children attending school. Investigating this association has important implications. The demonstration of a clear association between the FODMAP load in school lunches and AP could result in recommending dietary modifications to decrease the rate of AP and its negative influence in school attendance and quality of life [11,12].

We conducted the first investigation to assess the effect of variable FODMAP loads during lunchtime in schoolchildren. The primary aim of the study was to assess the relationship between FODMAP load, portion sizes consumed and AP in a sample of schoolchildren. We hypothesized that: 1- higher FODMAP diet triggers AP in healthy community children, 2- higher FODMAP content results in higher frequency and severity of AP, 3- children with a history of AP will be more likely to develop AP on days of higher FODMAP load, and 4- children who report AP following the meal will limit their portion sizes.

Materials and Methods

Recruitment: Study information was sent to the families of schoolchildren (8 - 12 years of age). Parents completed informed consent that concealed the aims and hypotheses of the study to minimize bias. The questionnaires provided information on demographics, past medical history (including history of AP) and food exclusions. Children with organic gastrointestinal diseases, metabolic diseases, and neurologic abnormalities were excluded from the study.

Protocol: A group of local licensed dieticians (LV, MCJ) with almost three decades of experience in providing school-lunches participated in the design of the study, calculated portions, FODMAP amounts, and advised on the characteristics of standard school lunches of Argentinian children. The team of local dieticians also assured that the lunches provided did not deviate from usual school lunches with the exception of the FODMAP load of the meal. The school lunches were prepared and delivered by a third-party food service company that serves approximately 10,000 school meals daily. The company certified the type and quantity of components.

At lunchtime, schoolchildren received a meal with varying FODMAPs loads. In order to assure the similarity in other non-FODMAP dietary components, the diets were matched for calories, protein, carbohydrates, and fat. The FODMAP content of a typical meal, supplied by the food company, was determined from 10 randomly selected days throughout the year. This served as a baseline for establishing FODMAP levels to develop meals with higher and lower amounts of FODMAP. The range of FODMAP load of the standard Argentine meal was calculated to be between 18g - 26g. The intervention lasted for one week, in which four out of five weekdays the children received either lower or higher FODMAP. On Monday and Tuesday, children were provided with a lunch containing higher FODMAP load (average: 39.2g), followed by a one-day washout period with a standard school lunch. Lower FODMAP load (average: 13.9g) lunches were served during the last two weekdays.

During lunchtime, the dietitians kept records of food consumed versus food wasted to calculate FODMAP content provided and consumed. Consumed portions were calculated as 0%, 25%, 50%, 75% or 100% of the total serving. Three hours after the meal, participants completed confidential standardized questionnaires to assess their AP. Children were advised to self-report presence and severity of AP on a numeric rating scale (0-10) [13], 0 experiencing no pain and 10 experiencing the worst possible pain. Based on studies on minimal clinical important difference of AP in children, those with a pain severity of ≥ 3 were considered as having AP [14]. Confidential questionnaires were collected by the research team upon completion.

Children were unaware that their meals had been manipulated. The study was approved by the IRB committee of the Hospital Posadas located in Buenos Aires, Argentina and by the principal of each school.

Statistical analysis: Fisher's exact test was used to calculate two-tailed P value for categorical variables when appropriate. Student's t-test was used to calculate differences in AP severity. Statistical significance was set at $p < 0.05$.

Results

One hundred and forty-nine out of 170 families (87.6%) invited to the study agreed to participate. Three children were excluded for organic diseases (celiac disease, hypothyroidism, and epilepsy). In total, 146 subjects completed the study. Five hundred and sixty meals were served (287 "higher FODMAP" meals and 273 "lower FODMAP" meals) over the course of the four days of the intervention.

Hypothesis 1 and 2- Relationship between FODMAP load and AP following meals

Overall, fifty-four children (37%) developed AP on at least one of the intervention days. Thirty-eight children reported AP on at least one of the higher FODMAP days, and 38 children reported AP on at least one of the lower FODMAP days. When comparing combined days of lower versus higher FODMAP loads, we found no significant association between the FODMAP load and development of AP ($p = 0.2808$) (Table 1). Nor was there a significant association between FODMAP loads and severity of AP (Table 2 and 3).

Day	Children with abdominal pain	Children without abdominal pain	p value
Day 1 [Higher FODMAP]	23 / 145 (16%)	122 / 145 (84%)	p = 0.6392
Day 2 [Higher FODMAP]	26 / 142 (18%)	116 / 142 (82%)	
Day 4 [Lower FODMAP]	32 / 139 (23%)	107 / 139 (77%)	p = 0.4567
Day 5 [Lower FODMAP]	25 / 134 (19%)	109/ 134 (81%)	
Day 1 and 2 combined	49 / 287 (17%)	238 / 287 (83%)	p = 0.2808
Day 4 and 5 combined	57 / 273 (21%)	216 / 273 (79%)	

Table 1: *Relationship between FODMAP load and abdominal pain following the intervention meals.*

Group	Higher FODMAP meals	Lower FODMAP meals	p value
N	287	273	p = 0.1865
Average pain severity **	1.16	1.42	
SD	2.12	2.48	

Table 2: *Relationship between FODMAP load and abdominal pain severity following the intervention meals*.*

**For all meals combined.*

***Numeric Rating Scale (NRS).*

Group	# of higher FODMAP meals associated with pain	# of lower FODMAP meals associated with pain	p value
N	49	57	p = 0.2475
Average pain severity**	5.33	5.79	
SD	2.05	2.04	

Table 3: *Relationship between FODMAP load and abdominal pain severity among children who reported abdominal pain following the intervention meals*.*

**For meals associated with AP.*

***Numeric Rating Scale (NRS).*

Hypothesis 3- Relation between history of AP and development of AP following the intervention meal

Those with a history of AP were not more likely to develop AP with higher FODMAP meals than those without a history of AP (p = 1.0000). Of the 50 subjects with a history of AP prior to the intervention, 12 (24.0%) experienced AP following one or more of the higher FODMAP meals. Out of the 96 children without a history of AP, 23 reported AP following the meal (23.96%) (Table 4).

Group	History of AP	No History of AP	p value
N	50	96	p = 1.0000
AP following the meal	12	23	

Table 4: *Relation between history of AP and development of AP following the intervention meal.*

Hypothesis 4- Relation between AP and portion size consumed

In total, 106/560 meals were associated with AP. Forty-nine higher FODMAP meals were associated with AP (17.07%) with an average consumption of 74.5% of the meal served. Fifty-seven lower FODMAP meals were associated with AP (20.88%) with an average consumption of 72.8% of the meal served. Table 5 shows children that reported AP following the meal ate a smaller portion size (73.6%, SD = 0.25) than children who did not report AP (85.4%, SD 0.20). Children consumed smaller portions on days of AP regardless of the FODMAP load (Higher FODMAP days (p = 0.0017), lower FODMAP days (p = <0.0001). There was no difference in portion size consumed on days of AP between higher and lower FODMAP days (p = 0.87).

	Abdominal Pain Associated with Meals		p value
All meals combined	**Yes**	**No**	p = 0.87
N	106	454	
Mean portion size consumed	73.58%	85.41%	
SD	0.2508	0.1994	
Higher FODMAP days			p = 0.0017
N	49	238	
Mean portion size consumed	74.49%	84.87%	
SD	0.2366	0.2034	
Lower FODMAP days			p = <0.0001
N	57	216	
Mean portion size consumed	72.81%	86.11%	
SD	0.2642	0.1954	

Table 5: *Relation between meals and portion size consumed.*

Discussion

This is the first study to assess the impact of variable FODMAP loads in heathy schoolchildren. Few studies have been conducted on the effect of FODMAP in children with abdominal pain [10,15].

Based on adult studies and a study completed by Chumpitazi., *et al*. [15,16], that showed that FODMAP load triggers abdominal pain symptoms in subjects with IBS, we projected that children would report differences in abdominal pain when FODMAP loads were manipulated. Contrary to our hypothesis, children did not develop more frequent or severe AP with increasing FODMAP load. Moreover, we did not notice worsening pain in children with a previous history of AP. The results of our study may seem to imply that, in fact, higher FODMAP content may not be the trigger of AP in healthy schoolchildren. This is of particular relevance considering that the standard meal in Argentina seems to have an even higher content of FODMAP compared with the diet in other parts of the world [17].

Our findings do not preclude that FODMAP intake could trigger AP in children with IBS. Distinctly than the Chumpitazi., *et al*. study, our study focused on the community rather than a small subset of children with IBS (n = 23). The diagnosis of IBS is only present in a small proportion of children who report AP in school. While the weekly prevalence of AP in a school-based study in Chicago was 38% [2], only 2.8% [18] and 5.1% [19] of American children and 7% of schoolchildren in Argentina [1] fulfill criteria for IBS per Rome III and IV criteria, respectively. Other factors may explain the high prevalence of AP in these otherwise healthy children during the school year.

The microbiome may be the key to explain the high frequency of AP reported by children following the meals regardless of the FODMAP load as gut microbiome differences have been observed in children with functional abdominal pain disorders [20]. A pediatric study found a different microbiome profile in the subset of IBS children that benefitted from a low FODMAP diet [10]. Studies have also shown that the microbiome of school-age children with and without functional abdominal pain disorders differs [21]. Another study found variations in alpha-diversity comparing school term and vacation term in children without functional abdominal disorders while the microbiome was stagnant in those without these types of disorders [20]. Future studies should investigate the microbiome of schoolchildren to assess if the microbiome could also predict who will develop AP regardless of the FODMAP content.

Children who reported AP hours after the meal ate smaller portions regardless of FODMAP content. This may suggest that some children recognize the threat of AP following a meal, and only those who experience AP following meals limit the portions for fear of developing AP. Studies investigating the association between abdominal pain and eating disorders among school-aged children is scarce. One study found that adolescents with irritable bowel syndrome (IBS) frequently reported eating-associated symptoms and those were correlated with altering their eating behaviors and consuming fewer total calories [22]. In adults, there are multiple studies indicating a correlation between functional gastrointestinal symptoms, eating disorders, and eating competence [23-25].

AP is highly prevalent in schoolchildren. We found that not only more than one third of children in the study reported AP after meals, but also that more than one third of children reported AP in the previous weeks. Our study underscores the importance of allocating resources to the study of AP in children. The vast impact of AP on the child's quality of life [26] and the high pain-related costs of care [27] highlight the importance of investigating the various factors causing AP in children.

There are clear strengths to underline in this study. The school-based nature of the investigation, relatively high sample size, and the fact that parents and children were blind to the aims of the study to minimize bias. We had high adherence to the protocol, which is a common caveat of dietary based studies [28]. We were also able to enlist the participation of local highly experienced dietitians who manipulated school lunches safely and within the constraints of a typical Argentine meal. To our knowledge, no previous studies have modified the FODMAP content of school lunches while maintaining the characteristics of the remaining components of the diet.

Limitation of the Study

Some of the limitations include the inability to generalize the results to all schoolchildren in Argentina or other regions of the world. We also did not used validated questionnaires to diagnose DGBIs within our sample. However, the aim of the study was to assess how the manipulation of FODMAP content would affect the general community with children who report AP regardless of a DGBI diagnosis.

Additionally, the cost and complexities of the design of our study limited the duration of the intervention to a relatively short period. We also recognize that providing children with even higher or lower FODMAP content could have been of interest; however, the meals were matched for calories and macronutrients to ensure the meals did not vary in substance except for FODMAP content. It is unclear whether further substantial increase or decrease in FODMAP content would have changed the results of this study.

Conclusion

In conclusion, AP is highly prevalent in schoolchildren in Argentina. Our study suggests that variations in FODMAP load does not result in changes in frequency or severity of AP in generally healthy schoolchildren and likely does not explain the high prevalence of AP in children during the school year. Children that develop AP after meals consequently eat smaller portions. It is possible that schoolchildren consider meals as triggers of AP limiting the portion size. Large studies in different populations are recommended to reproduce our findings and to test the external validity of our results.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, CIOMS guides (2016), the resolution of the national ministry of health n°1480/11 and also personal data protection law n° 25326 (habeas data), was approved by the Institutional Review Board of the Hospital Posadas in Buenos Aires, Argentina (registration code for the CEIHP, ref: 396EMnPeS0/20) date of approval: 7/15/2020).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy and ethical restrictions.

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Conflicts of Interest

The authors declare no conflicts of interest.

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