

The effects of increased dietary fiber intake on the self-reported quality of life of school-age children

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ABSTRACT

The aim of this community-based, randomized-controlled prospective nutrition intervention study was to assess the impact of serving high-fiber snacks twice a day to a sample of school-age children on their dietary fiber intake and health-related quality of life (HRQOL) scores. Participants (n = 81) were children aged 7 - 11 years. Children were randomized to receive two high-fiber snacks per day for eight weeks (intervention) or to continue eating their regular snacks (control). At baseline and post-intervention, usual dietary intake data were collected via repeated 24-hour dietary recalls and HRQOL was assessed using the PedsQL™ Pediatric Quality of Life Inventory. Statistical analysis to assess significant changes in dietary intake as well as self-reported quality of life was conducted using two-sided student's t-tests; significance level was set at $p < 0.05$. Dietary fiber intake increased significantly by 2.41 grams/day in the intervention group. The mean increase in the physical scale score of the PedsQL from baseline to post-intervention was significantly greater for the intervention as compared to control group. This study indicates that providing high-fiber snacks to elementary-school children can effectively increase dietary fiber consumption and may lead to an improved physical quality of life. Further research is needed regarding the impact of nutrition on health-related quality of life.

KEYWORDS

Quality of Life; Children; Fiber Intake; School Snacks

1. INTRODUCTION

Data on health-related quality of life (HRQOL) capture the physical, emotional, and social dimensions of well-being. Children may self-report HRQOL, providing unique insight into how they perceive their own HRQOL; or, information may be gathered via parent proxy-reports, which reflect caregivers' impressions of the external state of the child [1]. HRQOL assessment tools have historically been employed in acutely and chronically ill children [2], but are now increasingly utilized in healthy populations. Accordingly, a variety of questionnaires are available to assess both general and disease-specific HRQOL in child populations [2]. While the value of assessing healthy children's self-reported HRQOL has become increasingly recognized in the research and clinical communities, very few studies have focused on the impact of nutrition on HRQOL in healthy child populations.

Overweight and obesity are factors that affect HRQOL and are the result of an imbalance between caloric intake and expenditure. The established effects of overweight and obesity on children's HRQOL may provide insight into the potential relationship between nutrition and HRQOL. Overweight and obese children generally self-report a lower HRQOL than their normal-weight peers [3-7], although this impact may vary depending on the degree of overweight and the aspect of HRQOL examined [8]. Weight-loss interventions utilizing diet and/or exercise components can improve HRQOL scores, but the complex relationship between the effects of the weight loss itself and/or the improved feeling of well-being associated with exercising, such as dopamine release, makes it difficult to determine the contribution of dietary changes to HRQOL in weight loss situations [5].

One study that specifically examined the effects of diet on HRQOL found that adolescents who consumed <35% of daily caloric intake from fat reported higher quality of

life on the emotional functioning scale of the Pediatric Quality of Life Inventory™ (PedsQL™) compared to adolescents with higher fat intakes [6]. Costarelli *et al.* noted that children adhering to a Mediterranean-style diet, (assessed by daily fruit and vegetable intake, weekly fish and legume intake, and limited consumption of fast food and sweets) reported higher HRQOL on the Kidscreen-27 questionnaire [9]. Carson *et al.* suggested that diet may impact diet-related quality of life by a variety of channels, including social interactions, personal satisfaction/satiety, economics, physical, and psychological factors [10].

Another well-known and important factor contributing to children's HRQOL is their digestive health status. Problems regarding digestive health are very common among children and negative symptoms can be alleviated with nutrition therapy. For example, as much as 10% of the child population in the United States suffers from chronic constipation, a condition is associated with lower self-perceived quality of life [11]. Consuming high-fiber foods is recommended for the prevention and treatment of functional constipation as high-fiber foods increase fecal bulk and reduce transit time through the gut. Whole grain is one source of dietary fiber, and intake of whole grain has been shown to have a prebiotic effect on beneficial gut bacteria [12,13]. Adequate dietary intake of whole grain is recommended for general digestive health and is used as a marker of diet quality. Furthermore, it is generally recognized as beneficial in the prevention and treatment of heart disease and diabetes [14,15]. While multiple studies report increased grain intake in both youth [16] and adults [14] over the past 30 to 50 years, intake of dietary fiber in the US population has remained suboptimal [16-18]. Currently, less than 3% of children meet the Institute of Medicine's Dietary Reference Intake Adequate Intake (AI) recommendation of 14 grams of fiber per 1,000 kcal of total energy consumed [19], which is equivalent to 25 g/day for children 4 - 8 years of age, 26 g/day for females ages 9 - 13 years, and 31 g/day for males ages 9 - 13 years, respectively [20].

The purpose of this study was to evaluate whether elementary-school children's dietary fiber intake and self-reported quality of life could be affected by providing twice daily high-fiber snacks. Therefore, we conducted a community-based, cluster-randomized, controlled, prospective nutrition intervention study to address the following specific aims:

- 1) to determine if providing high-fiber whole-grain snacks twice a day will lead to a significant increase in dietary fiber intake in children ages 7 - 11 years,
- 2) to determine if children's self-reported and parent proxy-reported HRQOL are affected by the consumption of two high-fiber snacks/day for eight weeks.

We hypothesized that providing high-fiber snacks would

lead to higher dietary fiber intake and would improve children's self-reported HRQOL. Considering the benefits of fiber consumption, we hypothesized that even in the absence of symptoms of clinical constipation, increased fiber intake would be beneficial to children's HRQOL.

2. METHODS

This study was nested within a larger, randomized controlled, community-based nutrition intervention trial. The Institutional Review Board for Human Research (IRB) at Purdue University approved this study.

2.1. Participants and Recruitment

The Tippecanoe County school board, administrators, and teachers agreed to participate in this study. Participants ($n = 81$) were boys and girls attending a rural elementary school in northwestern Indiana. Participants were recruited from eleven 2nd - 5th grade classrooms. The exclusion criteria were having food allergies, digestive diseases such as Crohn's disease or chronic diarrhea, or use of medication(s) that would alter/affect the child's digestive function. Children were recruited by posting flyers and distributing parental consent materials to children to take home to their parents. Consented child-parent dyads completed a screener survey to determine the presence of exclusion criteria and provided basic socio-demographic information using a questionnaire with standard questions adopted from the National Health and Nutrition Examination Survey (NHANES).

2.2. Procedures

Participants were randomized by classroom into a control group or intervention group. The intervention group received a choice of two high-fiber snacks twice a day for eight weeks during the school's snack times (one in the morning, one in the afternoon) while the control group consumed their usual snack foods. Children in the intervention group received their snacks at the school on weekdays, where snack choices and consumption of the study foods were monitored by a research assistant. On Fridays, snacks were packed out for each weekend day for each participant (two options per snack occasion, two snack occasions per day) and children were instructed not to share the snacks with any family members or friends and to return all uneaten portions on the following Monday so that research staff could record them.

To determine usual food intake and the nutritional impact of the intervention on dietary fiber consumption, dietary intake was assessed at three time points: pre-intervention (baseline), mid-intervention (4 weeks), and post-intervention (8 weeks) using two 24-hour recalls, one on a weekday and one on a weekend day (Friday-

Sunday). Dietary intake estimates were calculated by generating the two-day average dietary intake at each time point.

2.3. Measure of Quality of Life

The Pediatric Quality of Life Inventory 4.0 Generic Core Scales is a widely used validated tool that assesses HRQOL in healthy children as well as those who have chronic health conditions [21,22]. The PedsQL may be used to collect self-report data from children ages 5 - 18 and/or parent proxy-report for children ages 2 - 18 [1]. Children and parents completed the PedsQL assessment tool at baseline and at post-intervention. Parent surveys were completed and returned to the school within three weeks after having received the survey.

Each PedsQL survey is comprised of 23 questions divided into four scales: physical functioning (8 items), emotional functioning (5 items), social functioning (5 items), and school functioning (5 items). Each of the 23 questions is rated by the child (or parent) on a 5-point Likert scale (0 - 4), with zero indicating that the item is *Never a Problem* and four indicating that it is *Almost Always a Problem*. Survey answers are reverse scored and linearly transformed to a 0 - 100 scale (Table 1). With this scaling, higher scores indicate better quality of life. Scores for the four scales may be reported as a total score or as a physical and a psychosocial summary score. The psychosocial summary score is comprised of participants' responses to questions in the emotional, social, and school functioning scales [21]. In addition, parents and children completed a bowel regularity survey at baseline, mid-intervention, and post-intervention. At baseline only two children in the control group and three in the intervention group reported a score of 10 or less on the bowel health survey, (out of a possible range of 6 - 30, with higher scores representing better bowel function), suggesting that the children generally had good gastrointestinal health and were not suffering from constipation.

2.4. Study Foods

The snacks provided to the children in the intervention group were commercially available foods that had been selected based on fiber content and acceptability in children. To qualify as a study food, the snack had to contain between three and nine grams (g) of fiber per serving. The foods included breakfast cereals, breads, crackers and cereal bars (Table 2). At each snack occasion, two food

choices were offered that differed by no more than one gram of fiber; the total fiber content of the snacks served throughout the day ranged between 10 and 12 grams regardless of which snacks the children chose. In addition to the high-fiber snacks, one cup of skim milk was provided at each snack occasion to help children meet the need for increased fluid intake.

2.5. Measures and Statistical Analysis

Of the 81 consented participants, four failed to return the PedsQL survey and were therefore excluded from analysis. Per the PedsQL guidelines for interpretation and analysis of missing data, if >50% of the questions in a scale were not answered the scale score was not computed ("missing data"). If ≤50% of the questions in a scale were unanswered, this was classified as "skipped data" and the unanswered items were imputed by calculating the mean of the completed items in the scale to replace the skipped questions. PedsQL scores were imputed for children who completed the PedsQL at baseline but not at post-intervention (n = 7) using a simple linear regression analysis. In short, total, physical, and psychosocial scores were plotted with baseline being the independent variable and post-intervention scores as the dependent variable. Using the resulting regression equation, missing scale scores were replaced.

The change in scores between baseline and post-intervention was determined by calculating the score difference for each participant. These differences were then averaged for the intervention and control groups, respectively, and a two sided student's t-test was conducted to test the null hypothesis that the differences between baseline and post-intervention scores were equal to zero. The level of significance was set at p-values < 0.05.

3. RESULTS

Participating children were 7 to 11 years old (mean = 9.3, SD = 1). Racial and ethnic backgrounds were representative of the school population and reflect the demographic of this area (Table 3).

At baseline, 16.9% of parents (n = 13) failed to return the PedsQL survey as compared to just 5.2% of children (n = 4). However, 3.9% of children returned surveys with "missing" responses for one or more scales (n = 3) and 5.2% of children "skipped" questions in one or more scales (n = 4). None of the parent respondents returned surveys with missing or skipped answers at baseline. At post-intervention, 16.9% of parents (n = 13) failed to return the survey, as compared to 10.4% of children (n = 8). One parent returned a survey with missing responses and one returned a survey containing skipped questions; one child returned a survey with missing responses, and 7.8% of children (n = 6) returned surveys with skipped

Table 1. Scoring scheme: point allocation for each response.

	Never	Almost never	Sometimes	Often	Almost always
Raw scores	0	1	2	3	4
Scaled scores	100	75	50	25	0

Table 2. Snack items offered, grams of fiber per serving and kcal per serving.

Snack type:	Dietary fiber (g)	Kcal
Cereals/cereal bars		
Kellogg's® Frosted Mini-Wheats Little Bites® Chocolate	6	200
Kellogg's® FiberPlus® Cinnamon Oat Crunch	8	110
Kellogg's® Frosted Mini-Wheats Little Bites® Original	6	190
Kellogg's® Cracklin Oat Bran®	6	200
Kellogg's® Frosted Mini-Wheats® Bite Size Blueberry Muffin	6	200
Kellogg's® FiberPlus® Berry Yogurt Crunch	8	170
Kellogg's® NutriGrain® Bar	3	130
Kellogg's® Frosted Mini-Wheats® Big Bite	5	180
Kellogg's® Frosted Mini-Wheats® Blueberry	5	150
Kellogg's® Frosted Mini-Wheats® Strawberry	5	150
Kellogg's® Frosted Mini-Wheats® Touch of Fruit in the Middle Mixed Berry	5	150
Crackers		
Kellogg's® Special K® Snack Crackers-Savory Herb	4.5	180
Kellogg's® Special K® Crackers Multigrain	3	120
Kellogg's® All-Bran® Crackers Multi Grain	5	130
Breads/Bagels/English muffins		
Sara Lee Soft and Smooth White Bread with Whole Wheat®	3	180
Sara Lee Soft and Smooth 100% White bread with Calcium and Vitamin D®	3	180
Pepperidge Farm Deli Flats (Whole Grain White)®	5	100
Thomas 100% Whole Wheat Bagel Thins®	5	110
Pepperidge Farm Stone Ground Whole Grain Bread®	4	140
Thomas 100% Whole Wheat Mini Bagel®	3	110
Arnold Whole Wheat Bread®	5	130
Arnold Sandwich Thins®	5	100
Thomas Light Multi-Grain English Muffin®	8	110
Thomas Plain Bagel Thins®	4	110

Table 3. Demographic characteristics of the sample population and the school's population.

	Intervention (n = 33)	Control (n = 33)	Total sample (n = 66)	School population (%) (n = 1062)
Age				
Average	9.4	9.2	9.3	
SD	1.09	0.9	1	
Range	7 - 11	7 - 11	7 - 11	
Gender				
Male	15 (45.5)	17 (51.5)	32 (48.5)	
Female	18 (54.5)	16 (48.5)	34 (51.5)	
Race				
White	23 (69.7)	23 (69.7)	46 (69.7)	63.8
Black	0	1 (3.0)	1 (3.0)	4.6
Asian	3 (9.1)	0	3 (4.5)	7.8
Hispanic	3 (9.1)	5 (15.2)	8 (12.1)	17.9
Other	2 (6.1)	1 (3.0)	3 (4.5)	5.7
Missing	2 (6.1)	3 (9.1)	5 (7.6)	
Ethnicity				
Hispanic	4 (12.1)	6 (18.2)	10 (15.2)	
Non-Hispanic	27 (81.8)	20 (60.1)	47 (71.2)	
Missing	2 (6.1)	7 (21.2)	9 (13.6)	
Free/Reduced price meals*				
Free meals				432
Reduced price				57
Paid meals				573

*No information available for sample population, only for school-wide enrollment in the program.

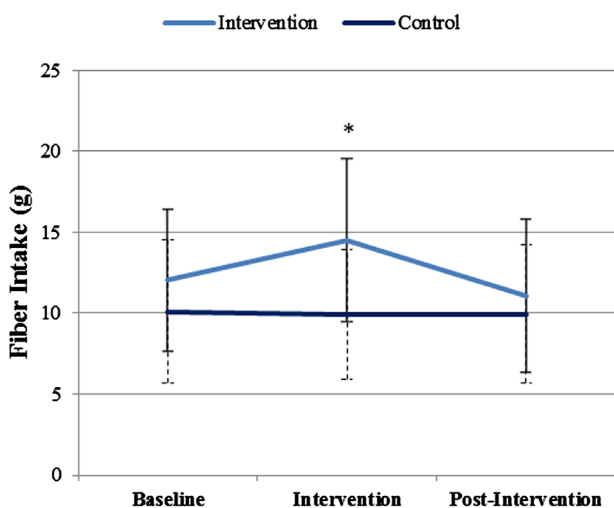
questions in one of the scales.

Analysis of correlations between parent and child PedsQL scores revealed low to medium effect sizes for total parent/child scores and for parent/child physical and psychosocial summary scores at baseline, (0.09 - 0.35); correlations rose post-intervention (0.19 - 0.70). Based on the higher percentage of survey non-response among parents, the lack of large correlations between parent and child scores at baseline, and children’s ability to self-report HRQOL information at this age [16], the analysis focused on children’s responses only.

After removing seven participants with missing baseline data and removing data from four participants with outlying PedsQL scores, n = 66 children remained in the analysis (51.5% girls), with 33 participants each in the intervention and control groups. Skipped child responses were imputed using the methods described above.

3.1. Fiber Intake

Average daily dietary fiber intake at each time point when dietary recalls were completed is shown in **Figure 1**. During 94% of all snacking occasions, children chose at least one snack and consumed 50% or more of the item. Although the sample was randomized by classroom, fiber intake was significantly higher in the intervention group at baseline (p = 0.035). At mid-intervention, mean daily fiber intake in the intervention group increased by 2.41 g (p = 0.028) but subsequently dropped by 3.65 g (p = 0.014) at post-intervention. The average fiber intake in the control group remained constant at approximately 10 g/day throughout the entire study period.



Note: Average fiber intakes shown are for all diet-compliant participants within the initial group of n = 81 children. (Control group: n = 37 at baseline and intervention; n = 36 at post-intervention. Intervention group: n = 34 at baseline and intervention; n = 32 at post-intervention.)

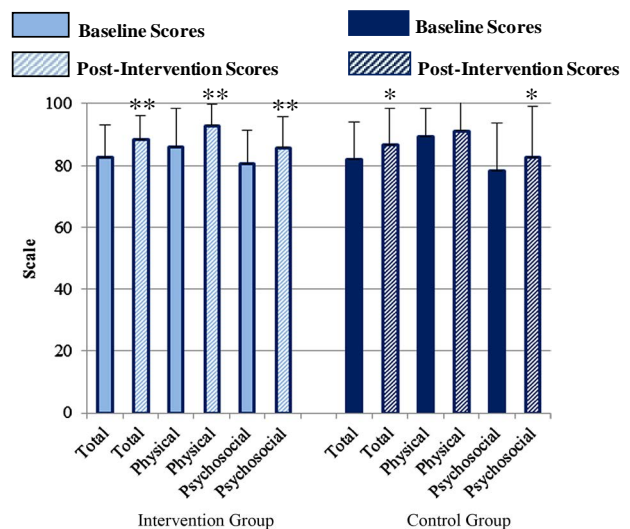
Figure 1. Fiber intake in the intervention and control groups at all time points.

3.2. Health-Related Quality of Life

The PedsQL physical, psychosocial, and total summary scores were compared between the intervention and control groups as well as between baseline and post-intervention. In both the intervention and the control group, all scores increased significantly from baseline to post-intervention, with the exception of the control group’s physical score (**Figure 2**). No significant differences between the intervention and the control group were observed for the summary scores or total score at baseline or at post-intervention. However, the increase in the physical health scale score from baseline to post-intervention was significantly greater (indicating better self-reported physical quality of life) in the intervention vs. control group (p = 0.031) (**Figure 3**). An ANOVA analysis of the difference between baseline and post-intervention physical scores correcting for gender and ethnicity showed no statistically significant effects of these covariates.

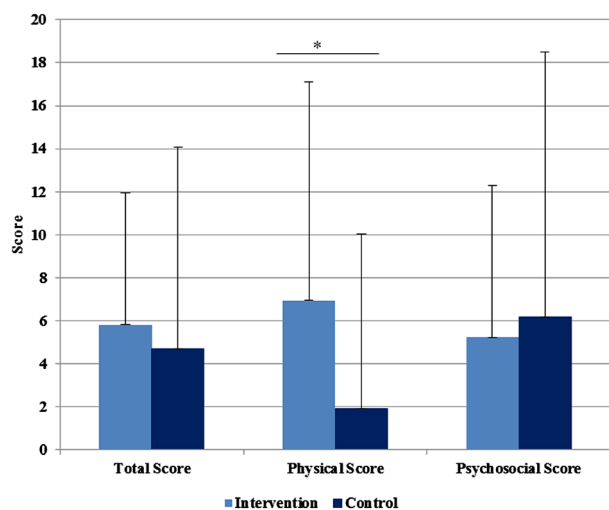
4. DISCUSSION

The nutrition intervention in this study resulted in a significant increase in dietary fiber consumption when children were provided with two choices of high-fiber snacks twice per day. Although self-reported HRQOL increased in all participants, the average increase in the physical health scale score was significantly greater for children in the intervention group compared to children in the control group. This finding may be related to the association between dietary fiber and more frequent defecation and lower prevalence of constipation-related symptoms. Thus, although the majority of the population



*Significantly greater than corresponding baseline score at p < 0.05; **Significantly greater than corresponding baseline score p < 0.001.

Figure 2. Total, physical and psychosocial PedsQL summary scores for the intervention group and control group, at baseline and post-intervention.



*Intervention score significantly greater than control ($p < 0.05$).

Figure 3. Mean differences between baseline and post-intervention PedsQL scores for intervention as compared to control group.

studied did not report digestive health problems, introducing more fiber into children's diets was beneficial and was associated with improved HRQOL.

Child response rates for the PedsQL assessment tool were high, indicating that the population studied was able to understand and use the survey. One limitation of the study was that children may have been less likely to have missing and skipped responses had the PedsQL surveys been completed with the assistance of the researchers. Likewise, parents' survey response rates were suboptimal, suggesting that researcher follow-up (*i.e.* by phone) might have resulted in higher survey completion rates. As results of this study showed, participating in the study led to higher correlations between child and parent PedsQL responses at post-intervention in both the intervention and control groups, suggesting that participation may have motivated parents and children to communicate about children's health and quality of life.

Many foods that are naturally high in dietary fiber—such as fruits, vegetables, nuts, seeds, legumes and certain whole grains—also have high nutrient density, and are therefore considered healthy food choices for children. Although the importance of consuming high-fiber and nutrient-dense foods has been communicated by the US government for several decades [23,24], most children consume a significant portion of their calories from calorically dense, low-fiber foods. Currently, three of the top four contributors to dietary fiber among US children ages 2 - 18 years are yeast breads and rolls; crackers, popcorn, pretzels and chips; and ready-to-eat cereal [25]. Analysis of national food disappearance data (used as a proxy for household intake) suggest an association between the increased intake of refined, enriched grains and the prevalence of obesity and diabetes in the adult

population, adding impetus to efforts which promote the consumption of foods that are naturally high in fiber, such as fruits, vegetables, and whole grains [26]. Nationally representative studies indicate that children with higher levels of dietary fiber intake consume significantly more fruits, vegetables and grains than children with lower dietary fiber intake [27]. Because many of the current primary contributors to dietary fiber intake are in fact low-fiber foods, replacing these items with higher-fiber (*i.e.* whole grain) alternatives could improve children's dietary fiber intake levels.

Overall, our findings indicate that snacks provided to children are a significant and modifiable source of nutrients in children's diets, and that serving high-fiber foods results in a significant increase in dietary fiber consumption and physical well-being. Nationally representative data analysis indicate that the vast majority of children do not usually consume high-fiber foods [19, 28]; thus, changes in school feeding policies to increase the provision of high-fiber food options would likely have a tremendous beneficial effect on average dietary fiber intake, increasing dietary fiber intakes to get closer to the recommended intake goal of 14 grams of fiber per 1000 kcal consumed.

As in all dietary intervention studies, this study has several limitations. The length of the intervention (8 weeks) might have been too short to have shown the full potential of increasing dietary fiber intake on school-age children's physical and psychosocial quality of life. Also, measures of dietary intake, bowel health, and quality of life were self-reported and may have been affected by reporting bias or error. It is possible that the observed improvements in HRQOL were mediated by other factors such as decreased levels of hunger (for children who otherwise would not have eaten), or feelings of well-being associated with participating in the study and receiving the study foods every day. Despite these limitations, the data strongly support offering children high-fiber foods during snack time as a mode to increase their fiber intake and their physical health, even in children who do not report symptoms of gastrointestinal distress. The fact that the average daily fiber intake fell to baseline levels as soon as the intervention had ceased indicates the importance of consistently serving healthy snack foods at school. The importance of school feeding was demonstrated by the fact that the children's home food environment did not change during the two months of intervention, although the children had increased familiarity with and high acceptance of high-fiber foods at school.

5. CONCLUSION

This study indicates that serving high-fiber snack foods twice a day at an elementary school was an effective tool

to significantly increase children's consumption of dietary fiber and led to an improvement in self-reported physical quality of life scores. Further research is needed to examine whether the effect of dietary changes on children's quality of life could be maximized by the use of long-term, multi-faceted interventions targeting improvements in over-all diet quality.

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