Bidirectional Associations between Fussy Eating and Functional Constipation in Preschool Children

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Objective To examine bidirectional associations between a child's fussy eating behavior and functional constipation.

Study design Participants were 4823 children enrolled in a prospective cohort study from pregnancy onward. We assessed fussy eating at age 4 years with the Child Eating Behavior Questionnaire, and assessed functional constipation using ROME II and III criteria with parental questionnaires at age 2, 3, 4, and 6 years.

Results Higher food fussiness at age 4 years was associated with a greater risk of functional constipation at both 4 years (OR, 1.30; 95% CI, 1.20-1.42; $P < .001$ per 1 SD increase) and 6 years (OR, 1.12; 95% CI, 1.03-1.23; $P < .05$ per 1 SD increase). The converse was also observed; previous constipation predicted a greater risk of being a fussy eater at age 4 years (constipation at 2 years: OR, 2.05; 95% CI 1.43-2.94; $P < .001$; constipation at 3 years: OR, 1.72; 95% CI, 1.26-2.35, $P < .001$). Path analyses confirmed that the association between fussy eating and functional constipation was indeed bidirectional, showing that functional constipation at age 3 years predicted fussy eater classification at age 4 years ($\beta = 0.06$; $P < .001$), which in turn predicted functional constipation at age 6 years ($\beta = 0.08$: $P < .001$) independent of each other.

Conclusion A vicious cycle might develop in which children with functional constipation develop unhealthy eating behavior, which in turn increases the risk of functional gastrointestinal disease. *(J Pediatr 2015;166:91-6)*.

Up to 50% of preschool children are "fussy" or "picky" eaters, characterized by the rejection of specific foods, both familiar and unfamiliar, resulting in a restricted variety of consumed foods and a less healthy diet.[1-6] Fussy eaters consume less green vegetables and fruits, foods high in dietary fibers and vitamins. This is often replaced by increased consumption of unhealthy foods with high sugar, salt, and/or fat content.[6-9] Our previous research indicated that compared with nonfussy eaters, fussy eaters have a history of lower vegetable and whole grain intake but a higher intake of ready-to-eat-meals and snacks.[5] This poor eating pattern contributes to the paradoxical situation in which an increasing rate of childhood overweight in Western countries is accompanied by essential nutrient deficiencies.[6] This situation might play an important role in the development of related health problems.

One of the most common pediatric health problems related to an unhealthy diet is constipation, which affects up to 30% of children in Western countries.[10,11] Childhood constipation affects the quality of life of affected children and their families and also impacts health care systems.[12,13] In the US, the annual cost of treatment of constipation in the general pediatric population is estimated at $3.9 billion.[14] Chronic constipation affects children's school attendance, peer group activities, and friendships.[15,16] The vast majority (90%-95%) of constipation in childhood is functional, occurring without an organic cause.[17] The etiology of functional constipation remains unclear but is likely multifactorial, involving genetic influences, behavioral factors such as physical activity, and dietary factors.[18-22] One of the most important dietary factors associated with constipation is low intake of dietary fiber.[23,24]

A recent cross-sectional study reported a higher prevalence of "picky eating" among children with clinical constipation compared with healthy controls (27% vs 13%).[25] The direction of the association between fussy eating and functional constipation remains unclear, however. Although it seems likely that fussy eating affects constipation through poor diet quality, it also can be hypothesized that constipation and the related abdominal pain are involved in the development of fussy eating. Fearful reactions to painful defecation are often observed in children with constipation. It has been suggested that this may result in learned behaviors such as stool-withholding, which in turn may increase pain, leading to persistent constipation.[26-28] It might be hypothesized that, similar to learned stool-withholding, painful bowel movements also might affect children's eating behavior and result in food fussiness.

CBCL	Child Behavior Checklist
CEBQ	Child Eating Behavior Questionnaire

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We examined bidirectional associations between children's fussy eating and functional constipation in a large population-based cohort study. We hypothesized that on the one hand, fussy eating is related to subsequent functional constipation, and on the other hand, functional constipation predicts fussy eating.

Methods

This study was embedded within the Generation R Study, a population-based cohort from fetal life onward.[29] All pregnant women living in Rotterdam, The Netherlands, with an expected delivery date between April 2002 and January 2006 were invited to participate (61% participation rate). The study was conducted in accordance with the guidelines proposed in the World Medical Association's Declaration of Helsinki and was approved by the Medical Ethics Committee of the Erasmus Medical Center, Rotterdam. More detailed information about the study design can be found elsewhere.[29]

Full consent for the preschool phase of the Generation R Study was obtained from parents of 7295 children. For 2351 of these children, no information on eating behavior was available, owing to nonresponse on the corresponding questionnaires. Children with information on eating behavior and at least 2 assessments of functional constipation were included in the study (n = 4823; 66% response rate).

Measures

Fussy Eating. Eating behavior was assessed at age 4 years using the Dutch version of the Child Eating Behavior Questionnaire (CEBQ).[30] The CEBQ consists of 35 items that assess food approach (eg, emotional overeating, enjoyment of food, food responsiveness, desire to drink) and food avoidance behaviors (eg, emotional undereating, satiety responsiveness, food fussiness, slowness in eating). Previous studies have shown the CEBQ to have good internal consistency, concurrent validity with observed eating behavior, test-retest reliability, and stability over time.[3,30,31]

We used 2 different approaches to assess the children's fussy eating behavior. First, we used the score on the "food fussiness" subscale of the CEBQ, consisting of 6 items (eg, "My child refuses to eat new foods at first") scored on a 5-point Likert scale from 1 (never) to 5 (always). Three items were reverse-coded. To calculate a food fussiness score, we summed the scores of each item and then corrected for the number of endorsed items ([raw score/number of endorsed items] × maximum number of items), with a maximum of 25% missing values allowed. The continuous food fussiness scores were *z*-standardized to facilitate interpretation. Higher scores indicate more food fussiness.

In the second approach we used a previously identified group of children from the present sample who we classified as "fussy eaters" using latent profile analysis of the CEBQ.[5] The children had been assigned to 1 of 6 eating behavior profiles based on Bayesian probabilities. The fussy eater group comprised approximately 6% of the children and was characterized by low scores on the CEBQ food approach scales and high scores on the CEBQ food avoidance scales.[5] In our second group of analyses, fussy eaters were compared with non-fussy eaters (ie, all other profiles identified with latent profile analysis).

At age 2, 3, and 4 years, the children were assessed for functional constipation during the previous year based on the ROME II criteria.[32] Children were classified with functional constipation if they had experienced at least 1 of the following symptoms for at least 2 consecutive weeks: 2 or fewer bowel movements per week and predominantly hard/firm feces.[22] At age 6 years, children were classified with functional constipation if they met at least 2 of the following criteria for at least 2 consecutive weeks: 2 or fewer bowel movements per week, predominantly hard/firm feces, and fecal incontinence.[33]

Analyses were adjusted for a number of sociodemographic (eg, sex, ethnic background, family income) and biobehavioral (eg, body mass index for age at the time of exposure, history of cow's milk allergy, maternal stress) factors (**Table I**), collected by postal questionnaires, from obstetric records, and during routine visits at the community well-baby clinics. Children were classified as non-Western if at least 1 grandparent was born in a non-Western country, based on parental report.

Maternal psychological stress was included as a confounder in the analyses, because it might affect how mothers perceive their child's health and behavior. We created a composite measure consisting of prenatal and postnatal maternal anxiety and depressive symptoms (Brief Symptom Inventory[34,35]), family functioning (Family Assessment Device[36]), and parenting stress (Nijmeegse Ouderlijke

Table I. Sample characteristics

Characteristics	Value
Functional constipation, n (%)	
At 2 y	503 (11.2)
At 3 y	695 (15.7)
At 4 y	684 (14.2)
At 6 y	652 (16.5)
Family characteristics	
Marital status single, n (%)	449 (10.4)
Maternal education, primary, n (%)	247 (5.3)
Family income <2563/mo, n (%)	642 (14.7)
Continued smoking during pregnancy, n (%)	552 (12.7)
Maternal BMI at enrollment, mean (SE)	24.4 (0.06)
Maternal age at enrollment, y, mean (SE)	31.6 (0.07)
Maternal stress composite score (0-1), mean (SE)	0.13 (0.01)
Child characteristics	
Non-Western, ethnicity, n (%)	1226 (25.6)
Male sex, n (%)	2407 (49.9)
Firstborn, n (%)	2730 (56.6)
Cow's milk allergy, n (%)	264 (6.1)
Never breastfed, n (%)	354 (9.1)
Snacking ≥1 time/day, n (%)	4209 (89.0)
Intake of sweet drinks, ≥1 glass/day, n (%)	4044 (85.2)
Television watching ≥2 hr/day, n (%)	321 (7.5)
Gestational age at birth, wk, mean (SE)	39.8 (0.03)
Birth weight, g, mean (SE)	3447 (8.17)
BMI SD for age at 4 y, mean (SE)	0.09 (0.02)

BMI, body mass index.
Snacking and intake of sweet drinks was assessed at age 4 years; television watching was assessed at age 3 years.

Stress Index–Kort[37,38]). We dichotomized each of these scores at the highest 15% (indicating high stress). Summed scores of high stress indices (ranging from 0 to 6 times in the highest 15% of scores) were created and then divided by the number of items endorsed (ranging from 4 to 6), resulting in a score of 0-1, with a higher score representing more stress.

Finally, we used 2 items from the Child Behavior Checklist (CBCL),[39] "does not eat well" and "refuses to eat," as a proxy for fussy eating at age 3 years. Item scores ranging from 1 (not at all applicable) to 3 (often applicable) were summed and then dichotomized at ≥4. Of the children classified as fussy eaters at age 4 years using the CEBQ, 65% also scored ≥4 points on the fussy eating proxy at age 3 years (vs 25% of the nonfussy eaters).

Statistical Analyses

Analyses were conducted with SPSS version 21 (IBM, Armonk, New York) and Mplus version 6.0 (http://www.statmodel.com/).[40] We first used logistic regression analyses to test whether fussy eating at age 4 years was associated with functional constipation at age 4 and 6 years. We then tested the reverse direction, that is, whether functional constipation at age 2 and 3 years was associated with fussy eating at age 4 years. We performed linear regression analyses to examine associations of functional constipation with food fussiness *z*-scores, and logistic regression analyses to examine associations of functional constipation with fussy eater classification. Analyses were adjusted for relevant confounders. Missing values for covariates and functional constipation were imputed in SPSS 21 using multiple imputation techniques if at least 2 assessments of functional constipation were available.

Finally, we conducted a path analysis to assess the direction of the association between fussy eating and functional constipation (**Figure**; available at www.jpeds.com). In this analysis, associations were adjusted for one another, which generated standardized coefficients that can be used to directly compare the strength of the associations assessed.[41] For example, the effect estimate for the association of fussy eating at age 4 years and functional constipation at age 6 years can be interpreted as being independent of the association between functional constipation at age 3 years and fussy eating at age 4 years. Path analyses were conducted with and without adjusting for the fussy eating proxy at age 3 years as assessed with the CBCL to take into account a baseline measure of fussy eating.

Results

The current study population consisted of 75% Western and relatively highly educated families with 2 parents (**Table I**). Approximately one-half of the children were boys, and one-half were firstborns. Most had been breastfed, and a minority had a history of cow's milk allergy in the first year of life. Functional constipation was reported in 11% of the children at age 2 years and in 16.5% at age 6 years.

Fussy Eating as a Predictor of Functional Constipation

Both measures of fussy eating at age 4 years were associated with functional constipation, cross-sectionally and longitudinally (**Table II**). Children with higher scores on the food fussiness subscale of the CEBQ had a higher risk of functional constipation at both age 4 years (OR, 1.30; 95% CI, 1.20-1.42; $P < .001$ per 1 SD increase in food fussiness score) and age 6 years (OR, 1.12; 95% CI, 1.03-1.23; $P < .01$ per 1 SD increase in food fussiness score). Likewise, children classified as fussy eaters at age 4 years had a higher risk of functional constipation at age 4 years compared with nonfussy eaters (OR, 2.24; 95% CI, 1.68-3.00; $P < .001$). Being a fussy eater at age 4 years also predicted a higher risk of constipation at age 6 years (OR, 1.91; 95% CI, 1.39-2.62; $P < .001$).

Functional Constipation as a Predictor of Fussy Eating

Compared with children without functional constipation, those with functional constipation at age 2 years had higher scores on the food fussiness scale at age 4 years and were twice as likely to be classified as a fussy eater (**Table III**). The same result was found for functional constipation at age 3 years, which predicted higher scores on the food fussiness scale and a greater risk of being a fussy eater at age 4 years.

Table II. Fussy eating at age 4 years and the risk of functional constipation at age 4 and 6 years

		Functional constipation at 4 years			Functional constipation at 6 years		
Child eating behavior at 4 years	Number	Pooled B (SE)	Pooled OR (95% CI)	*P* value	Pooled B (SE)	Pooled OR (95% CI)	*P* value
Food fussiness, z-score							
Model 1	4820	0.27 (0.04)	1.31 (1.21-1.42)	<.001	0.14 (0.04)	1.15 (1.06-1.26)	.001
Model 2	4820	0.27 (0.04)	1.30 (1.20-1.42)	<.001	0.12 (0.04)	1.12 (1.03-1.23)	.008
Fussy eater classification, yes/no							
Model 1	4796	0.95 (0.14)	2.58 (1.95-3.40)	<.001	0.82 (0.15)	2.28 (1.69-3.08)	<.001
Model 2	4796	0.81 (0.15)	2.24 (1.68-3.00)	<.001	0.65 (0.16)	1.91 (1.39-2.62)	<.001

Results of logistic regression analyses. Children with no functional constipation were considered the reference group. Model 1 is unadjusted. Model 2 is adjusted for maternal age, maternal education, marital status, monthly family income, maternal smoking during pregnancy, maternal history of eating problems, maternal stress, child ethnicity, sex, parity, gestational age at birth, weight at birth, cow's milk allergy, history of breastfeeding, child snacking behavior, child intake of sweet drinks, television watching, and BMI for age at 4 years.

Table III. Functional constipation at age 2 and 3 years and fussy eating at age 4 years

	Food fussiness (z-score)			Fussy eater classification			
	Number	Pooled B (SE)	*P* value	Number	Pooled B (SE)	OR (95% CI)	*P* value
Functional constipation at 2 years (yes/no)							
Model 1	4820	0.24 (0.05)	<.001	4796	0.88 (0.17)	2.42 (1.73-3.38)	<.001
Model 2	4820	0.25 (0.05)	<.001	4796	0.72 (0.18)	2.05 (1.43-2.94)	<.001
Functional constipation at 3 years (yes/no)							
Model 1	4820	0.28 (0.04)	<.001	4796	0.68 (0.16)	1.97 (1.47-2.63)	<.001
Model 2	4820	0.30 (0.04)	<.001	4796	0.55 (0.16)	1.72 (1.26-2.35)	.001

Results of linear and logistical regression analyses. Model 1 is unadjusted. Model 2 is adjusted for maternal age, maternal education, marital status, monthly family income, maternal smoking during pregnancy, maternal history of eating problems, maternal stress, child ethnicity, sex, parity, gestational age at birth, weight at birth, cow's milk allergy, history of breastfeeding, and BMI for age at time of exposure.

Direction of the Association between Fussy Eating and Functional Constipation

We conducted path analyses to test the direction of the association between fussy eating and functional constipation (**Figure**). Because effect estimates were very similar regardless of adjustment for the fussy eating proxy at age 3 years, only results of adjusted analyses are shown in the **Figure**. Associations between functional constipation and fussy eating remained significant in both directions when adjusted for the other and for stability effects of functional constipation over time. These results indicate bidirectional effects; functional constipation at age 3 years predicted both higher scores on the CEBQ food fussiness scale at age 4 years and fussy eater classification, which in turn predicted functional constipation at age 6 years, independent of previous associations, even when adjusted for fussy eating at 3 years.

Discussion

The results of this longitudinal study show that fussy eating in 4-year-olds is associated with concurrent functional constipation and predicts subsequent functional constipation. In addition, we found evidence for the converse, with functional constipation at a younger age predictive of fussy eating behavior at age 4 years. Those associations were independent of sociodemographic and biobehavioral confounders, such as cow's milk allergy, sedentary behavior, or maternal psychological stress. Path analysis models confirmed bidirectional associations between fussy eating and functional constipation in preschoolers.

Both fussy eating and functional constipation lack a universally accepted definition, which is one reason for the variation in previously reported prevalences. Fussy eating has been reported in 7%-30% of preschoolers in the general population.[1-4] We previously identified 5.6% of children as fussy eaters using latent profile analysis.[5] This is in line with reports of other studies using a data-driven approach to define fussy eating.[4] Estimates of the prevalence of functional constipation in children vary between 0.3% and 29.6%, also depending on the definition and the population.[10] In our population-based sample, we found prevalence rates of functional constipation as assessed by parental questionnaires based on ROME II/III criteria[32,33] ranging between 11.2% (at age 2 years) and 16.5% (at age 6 years). These prevalence estimates are comparable with those from other studies in the general population and school samples.[10]

Our results extend previous findings and suggest that a vicious cycle may develop throughout childhood, in which children's gastrointestinal problems and problematic eating behavior mutually affect each other. There are plausible mechanisms for both directions of the association between fussy eating and functional constipation. On one hand, fussy eating might affect the development of functional constipation through the lack of dietary fiber and other nutrients, which is characteristic of the diet of fussy eaters.[6-9] On the other hand, functional constipation in 2- and 3-year-olds predicts fussy eating at age 4 years. This pathway is less well studied, but it is conceivable that children with constipation and the accompanying abdominal pain and painful defecation may develop problematic eating behavior.[42] More research is needed to examine the role of digestive health problems for the development of fussy eating behavior.

Our findings have important implications for the treatment of functional constipation in children. Current medical treatment is not evidence-based and has shown limited success.[43-45] The UK National Institute for Health and Clinical Excellence recommends the use of laxatives for fecal disimpaction and long-term maintenance treatment[16,46]; however, there is no conclusive scientific evidence of the effectiveness of laxatives in treating constipation in children.[43,45] Recommendations are based on the effectiveness of laxatives in adults and might not apply to children because of differences in the etiology of constipation in the 2 age groups.[43] Furthermore, the use of laxatives might not be a good approach for long-term treatment of children.[43,44] Protocols for the long-term management of constipation already emphasize the importance of behavioral interventions to promote awareness of the condition and its causes, to improve toilet training and dietary habits, and to address anxiety and guilt in parents and children.[44,45,47] However, UK National Institute for Health and Clinical Excellence guidelines still only recommend diet and lifestyle interventions, such as increased vegetable and fruit intake and physical activity in combination with laxatives.[16,47]

Although more research is needed to establish causality of the associations that we have identified, our present findings indicate that awareness of the interconnectedness of fussy

eating and functional constipation might be beneficial for affected families, to help them better understand both conditions and relieve anxiety and guilt.[26] Behavioral interventions targeting fussy eating behavior in children might be a useful strategy in the treatment of functional constipation, because fussy eating behavior might be one of the reasons for the unhealthy dietary intake involved in constipation. Likewise, awareness of digestive problems in fussy eaters might help reduce some of the stress related to food fussiness in these children. Moreover, the treatment of fussy eating might be facilitated by the use of laxatives in children with constipation, if fussy eating is in part a learned behavior in response to painful bowel movements.

Our findings must be interpreted in light of several limitations. With the current data, we could not test whether functional constipation at age 2 and 3 years was preceded by a history of problematic eating behavior in infancy, because the CEBQ was applied only at age 4 years. However, to be able to take into account fussy eating behavior before age 4 years in our path analyses and test directionality of the associations, we used 2 questions of the CBCL that reasonably corresponded to the fussy eater classifications based on the CEBQ. Although we also adjusted our analyses for important confounding factors, residual confounding by unmeasured variables could have remained. Owing to the timing of data collection, the most recent version of the ROME criteria (ROME III) could be applied only to the assessment of functional constipation at age 6 years. The earlier assessments were based on ROME II criteria, which might have resulted in underestimation of functional constipation before age 6 years, because ROME II is less sensitive with regard to children's abdominal pain.[48] Indeed, in our study, the prevalence of functional constipation was highest at age 6 years, when the most recent criteria were applied. Considering that abdominal pain also might be related to children's eating behavior, the use of ROME II criteria also might have led to underestimation of the association between functional constipation and fussy eating.

Although our findings indicate a bidirectional relationship between fussy eating and functional constipation in young children, we cannot fully exclude the possibility that this association is caused by underlying factors related to both conditions that confound the association. We adjusted our analyses for several possible confounding factors, including history of breastfeeding and sedentary behavior, but residual confounding cannot be concluded. For example, it is well known that both fussy eating and functional constipation occur more frequently in children with pervasive developmental disorders.[49,50] In the present study, we explored the role of anxiety disorders, pervasive developmental disorder, attention deficit hyperactivity, and obsessive-compulsive symptoms assessed at age 3 years by maternal report with the CBCL, by adding them as confounders to our models (data available on request). Because this did not change any of the effect estimates describing the association between fussy eating and functional constipation at age 4 years, we did not include them in the subsequent analyses. Nevertheless, the role of these psychiatric problems in children for fussy eating and for functional constipation separately, which was beyond the scope of this study, warrants further research.

In conclusion, the present study shows that fussy eating and functional constipation are directly associated with each other and may set up a vicious cycle that exacerbates the situation. Our findings provide a better understanding of pediatric functional constipation, which is of interest for public health given the relatively high prevalence of functional constipation and its impact on affected children and their families as well as health care.[12-14] In addition, behavioral interventions might target fussy eating behavior to improve children's diets, with the added advantage of alleviating the constipation. ■

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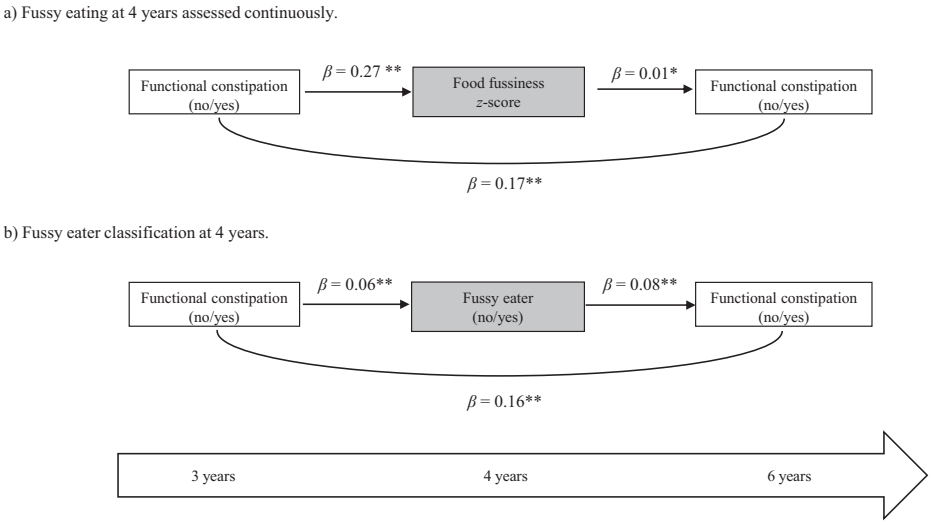

Figure. Path analyses of fussy eating and functional constipation (n = 4345). **A,** Fussy eating at age 4 years, assessed continuously, z-standardized. **B,** Fussy eater classification. Values for β and SE were obtained from pathway analyses conducted in Mplus, adjusted for all other paths and fussy eating at age 3 years. No other covariates were taken into account. $^{*}P < .05$; $^{**}P < .001$.