PRACTICAL ASPECTS

The Management of Dietary Fiber Intake in Children With Chronic Kidney Disease – Clinical Practice Recommendations From the Pediatric Renal Nutrition Taskforce

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The benefits of dietary fiber are widely accepted. Nevertheless, a substantial proportion of children fail to meet the recommended intake of dietary fiber. Achieving adequate fiber intake is especially challenging in children with chronic kidney disease (CKD). An international team of pediatric renal dietitians and pediatric nephrologists from the Pediatric Renal Nutrition Taskforce (PRNT) has developed clinical practice recommendations (CPRs) for the dietary intake of fiber in children and adolescents with CKD. In this CPR paper, we propose a definition of fiber, provide advice on the requirements and assessment of fiber intake, and offer practical guidance on optimizing dietary fiber intake in children with CKD. In addition, given the paucity of available evidence and to achieve consensus from international experts, a Delphi survey was performed in which all the clinical practice recommendations were reviewed.

Keywords: Fiber; Chronic kidney disease; Pediatric Renal Nutrition Taskforce; Clinical practice points; Children

Introduction

DIETARY FIBER HAS several health benefits and is considered an essential constituent of a healthy diet in adults and children.[1] Despite the established beneficial effects of dietary fiber, a substantial proportion of children fail to meet the recommended intake of dietary fiber due to a low consumption of whole grains, fruits, vegetables, legumes, and nuts.[2] This is especially true for children with chronic diseases such as chronic kidney disease (CKD). In a cohort of children with nondialysis CKD stages 1-5, only 23% of children met the recommended intake of dietary fiber for healthy children, and this decreased to 9% in

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children with CKD stages 4-5.[3] For children with CKD, achieving the recommended intake of dietary fiber is challenging due to the associated altered appetite inherent to the disease or its treatment, strict fluid restrictions, the use of exclusively tube feeding, and the discouragement of potassium-rich fruits, vegetables and whole grains to avoid hyperkalemia. Moreover, traditional dietary recommendations in CKD have predominantly focused on the quantities of individual nutrients such as calories, protein, salt, potassium and phosphate, while the supply of dietary fiber, fruit and vegetables, and the quality and diversity of the diet were often overlooked.[4]

A growing body of evidence from studies in adult patients suggests that dietary fiber intake and plant-based diets are of particular interest for patients with CKD. Adequate fiber intake promotes gut motility and increases the stool viscosity, tackling the prevalent problem of constipation in patients with CKD.[4] Higher dietary fiber intake in adult CKD patients also resulted in a greater decrease in inflammation as well as cardiovascular disease and mortality in comparison to patients without CKD, suggesting an additional role for dietary fiber in patients with CKD.[5] These beneficial effects were reported in kidney transplant recipients as well as patients on dialysis.[6-9] Importantly, a higher dietary fiber intake in patients with CKD can shift the gut microbiome toward increased production of anti-inflammatory compounds and reduced production of gut-derived uremic toxins, which are toxic metabolites that accumulate in advanced CKD and are associated with many complications, including cardiovascular disease, infections, cognitive dysfunction and pruritus.[10-16]

Although the benefits of dietary fiber are well-established, current nutritional guidelines for patients with CKD provide little practical guidance as to how dietary fiber prescriptions should be implemented in clinical practice while balancing potential risks such as hyperkalemia.[4] Therefore, the Pediatric Renal Nutrition Taskforce (PRNT) has developed clinical practice recommendation (CPR) to guide health care practitioners in the management of dietary fiber intake in children with CKD stage 1-5, treated with dialysis and who received kidney transplantation, with a focus on its gastrointestinal benefits. The definition, sources, assessment, and recommendations for fiber intake in the diet of children with CKD are discussed, including practical aspects of dietary modifications.

Methods

The composition of the PRNT, the detailed development process for CPRs, grading of evidence, and plans for audit and revision of the CPRs have been described in previous guidelines.[17,18] Briefly, evidence review and CPR development was performed by the core group of PRNT members and reviewed through a Delphi consensus process by a voting panel.

The Patient, Intervention, Comparator, and Outcome Questions

The Patient, Intervention, Comparator, and Outcome (PICO) format was used to address questions within the CPR.[19] To make the recommendations practical and applicable to routine clinical practice, the PICO questions provide specific actionable advice on choosing between alternative approaches in the management of dietary fiber intake. The PICO terms defined were:

Population

Children and adolescents (1-18 years) with CKD stage 1-5, stage 5D on dialysis, and after kidney transplantation.

Intervention

Fiber intake in children and adolescents with CKD stage 1-5, stage 5D on dialysis, and after kidney transplantation.

Comparator

Fiber intake in age-matched healthy children and adolescents, or no comparator.

Outcomes

Bowel function in children with CKD stage 1-5, stage 5D on dialysis, and after kidney transplantation.

These PICO elements were addressed through discrete questions that were used in the literature searches. Each PICO question then formed the basis for a recommendation. The PRNT acknowledges that there may be other potential benefits of fiber intake such as decreased production of gut-derived uremic toxins, a reduced inflammatory state, and improved cardiovascular outcomes, but given the paucity of studies evaluating these outcomes in children, we have not addressed them further in this CPR.[1] In this guideline we focus on the effect of fiber on bowel function (ie, intestinal transit time and stool bulk). The pharmacological management of constipation has been recently published by our group and is not within the scope of this document.[20] Children under 1 year of age are not included in this CPR given their unique dietary needs.[21]

Literature Search

We searched for publications on PubMed, Medline, Embase, and the Cochrane library between 1980 and 2023 period. Publications on dietary fiber types, sources, intake and effects in healthy children and those with CKD were critically reviewed and used to make up-to-date recommendations for children with CKD. Details of literature search criteria are described in Table S1. As there are only a few randomized controlled trials (RCTs) on the requirements or effects of fiber intake in children with CKD, or of the relative benefits of different types of fiber in healthy children or in children with CKD, observational and retrospective studies were also included. Due to the lack of high-quality studies, we have included all studies with findings relevant to outcomes, irrespective of patient numbers, or duration of follow-up. Also, RCTs and meta-analyses in adults with CKD have been reviewed, and where appropriate, these findings have been extrapolated to pediatric practice. In the absence of suitable studies, the opinion of experts from the PRNT is provided, which must be carefully considered by the treating dietitian and physician, adapting to individual patient needs as appropriate.

Framing Advice

After critically reviewing the literature for each PICO question, we derived CPRs and graded them as suggested by the American Academy of Pediatrics (Table S2).[22] Using the Delphi method, voting group members were sent an e-questionnaire to provide a level of agreement on a 5-point scale (strongly agree, agree, neither agree nor disagree, disagree, strongly disagree) and given the opportunity for rewording of recommendations if appropriate. Failing a 70% level of consensus, recommendations were adapted after discussion in the core group, and reviewed again by the voting panel until a consensus level of at least 70% was achieved. The Delphi process has been described previously.[17,18]

Clinical Practice Recommendations

1. What are dietary fibers?
   - 1.1 Dietary fibers are carbohydrate polymers (defined as containing 3 or more monomeric units) that are not digested nor absorbed in the human intestine, or associated noncarbohydrate plant cell wall compounds. (Ungraded).
   - 1.2 Carbohydrate polymers are naturally present in food (known as intrinsic fiber), or chemically/physically extracted, enzymatically modified or synthetically derived (known as added fiber). Carbohydrate polymers include three major groups: (1) non-starch polysaccharides (NSP); (2) resistant oligosaccharides (RO); and (3) resistant starch (RS). Non-carbohydrate plant cell wall (NPC) compounds such as lignins, chitins, and waxes are also included in the definition of fiber. (Ungraded).
   - 1.3 Fibers (intrinsic and added) are required to have beneficial physiological effects in humans for inclusion in the definition. (Ungraded).
   - 1.4 The official method of quantifying the amount of fiber in a food component as recommended by the Association of Official Analytical Chemists International (AOAC) has been followed in this CPR. (Ungraded).

Rationale

Several definitions of fiber have been proposed and are summarized in Table S3.[2,23] For this CPR, the PRNT has adopted the comprehensive definition of dietary fibers from the internationally recognized definition proposed by the CODEX 2009.[23,24] The CODEX Alimentarius is an important document providing definitions and standards for food safety, quality, and trading.[25] Other definitions summarized in Table S3 are mainly local recommendations. Although there is broad agreement between the definitions, there are several differences which result in regional variations in nutrition labeling, food composition tables, and (inter)national recommendations. First, definitions differ as to whether noncarbohydrate substances such as lignins, chitins, and waxes are included in the definition. Second, a variable minimum number of carbohydrate monomeric units (≥3 or ≥10 units) have been included in different definitions. Third, definitions were based on different methods of fiber analysis and quantification. The method proposed by the AOAC, a method that has been improved over time and changed as the definition evolved, is most often applied internationally in the guidelines (including CODEX), while some food databases still use the older Englyst or Southgate method.[2,23] Fourth, some definitions only include fibers (intrinsic and/or added fiber) with demonstrated health benefits (Table S3). To help meet the daily requirement of fiber, the CODEX 2009 included extracted, modified and/or synthetic fiber with demonstrated health benefits in their definition. The beneficial effects that CODEX 2009 refers to are: (1) improved intestinal transit time and increased stool bulk; (2) improved fermentation by colonic microflora; (3) a reduction in blood total and/or low-density lipoprotein (LDL) cholesterol levels; and (4) a reduction in postprandial blood glucose and/or insulin levels. Table S4 provides an overview of all added fibers, with corresponding E-numbers when assigned, included by the CODEX.[24] Although there is scientific evidence that isolated fibers do show health benefits, it should be emphasized that the supply of a wide range of protective nutrients and phytochemicals present in natural fiber sources are lacking in the category of extracted, modified, and/or synthetic fibers.[23] Therefore, in this guideline we introduce the term ‘added fiber’ versus ‘intrinsic fiber’ to distinguish between chemically/physically extracted, enzymatically modified or synthetically derived fiber, and natural fiber sources. Finally, as suggested by several guidelines, the terms ‘soluble’ versus ‘non-soluble’ fiber have not been used in our guideline, as this terminology needs to be phased out as the solubility of a particular fiber is not related to its physiological effects.[26] Figure 1 provides an overview of the different types of fiber, including its solubility and sources.

2. What are the main sources of fiber in the diet of healthy children and adolescents?
   - 2.1 The main sources of fiber in a child’s diet include grain products, fruit, vegetables,

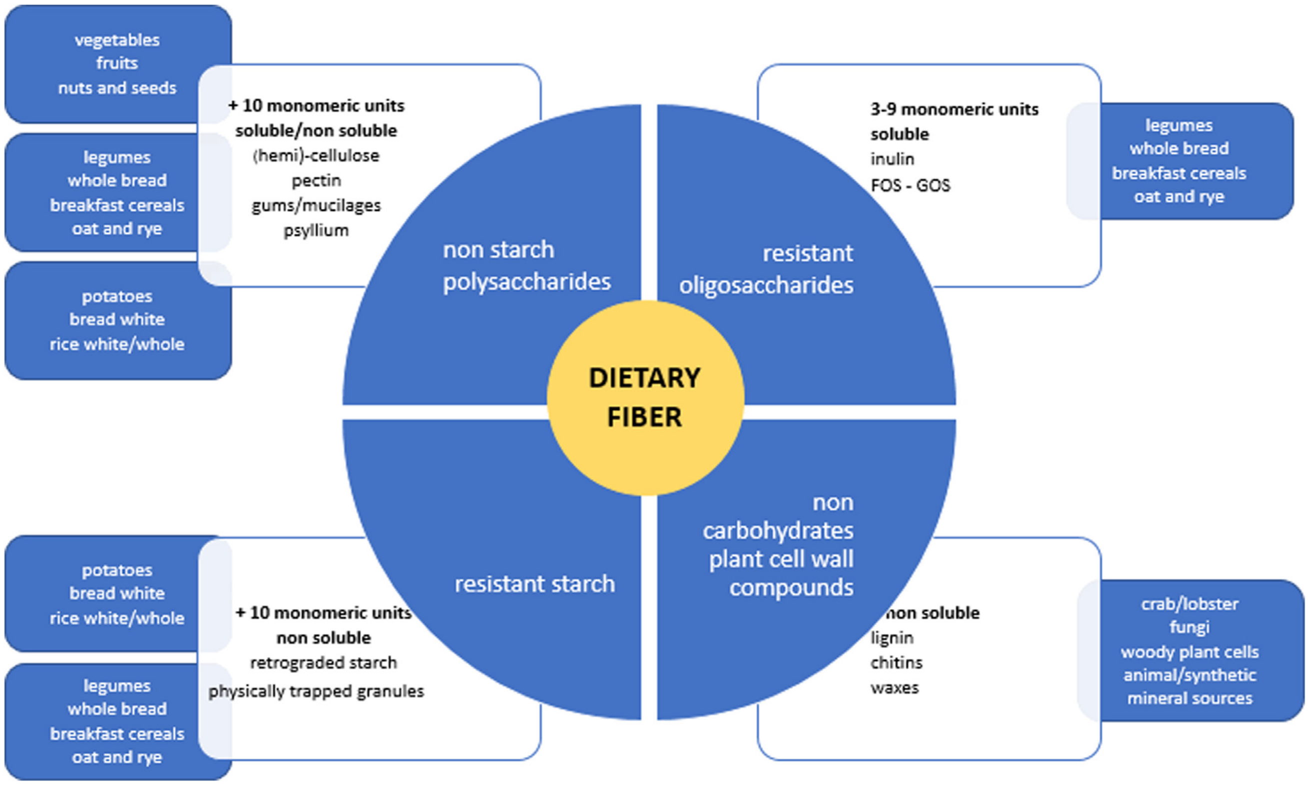

Figure 1. Four different major groups of dietary fiber: (1) nonstarch polysaccharides (NSP); (2) resistant oligosaccharides (RO); (3) resistant starch (RS), and (4) noncarbohydrate plant cell wall (NPC) compounds. For each group, characteristics such as amount of monomeric units and (non)-soluble fibers are shown. At last, typical food sources are also summarized per major group of dietary fiber.

potatoes, and legumes. The percentage of fiber contributed by different foods varies by geographical region and local eating patterns. (Ungraded).

2.2 Fiber added to processed foods contributes to the total daily fiber intake. (Level D; weak recommendation).

Rationale

Data from national surveys assessing food sources of fiber suggest that grain products (bread, breakfast cereals, pasta, biscuits, and pastries), fruits, vegetables, potatoes, and legumes are the main contributors of fiber intake (Table S5).[27-29] There are large geographical differences in the main sources of fiber (Table S5 and Figure S1). For example, grain products are the main source of fiber in Australia, Belgium, Germany, Italy, Sweden, UK, and USA; conversely the main sources of fiber in France and Spain are fruits and vegetables. These differences reflect regional food availability, eating habits and varied practices of fortifying foods with fiber. Research in fiber intake in different age groups in Australia and the UK shows less difference in sources of fiber intake between age groups with the exception of fruit intake, which is highest in young children when compared to adolescents.[2] Results of the 2016 Feeding Infants and Toddlers Study (FITS) revealed that the group of children consuming the highest amount of dietary fiber was likely to have had higher intakes of nut butters, legumes, fruits, and vegetables. Also, more of the grain products they ate were whole grains.[30] Fiber contents of typical foods per portion, and per 100 g, are shown in Table 1. Of note, foods naturally rich in fiber also contain other beneficial compounds such as vitamins, minerals, and anti-inflammatory compounds.[4,33,34]

Foods processed and enriched with added fiber for a specific physiological or health benefit also contribute to the total daily fiber intake.[23] All added fibers recognized by the CODEX are summarized in Table S3.[26] As summarized in Table S6, the food industry in Europe and the UK must follow strict criteria in labeling a food product with health claims such as “a source of fiber” or “high in fiber”, and the fiber content must be provided in the nutrition information on the package when a claim is used.[35] The labeling in Australia, Canada, and USA is similar but not identical (Table S6).

Although processed foods enriched with added fiber are accepted as sources of fiber, these products do not necessarily provide other beneficial nutrients present in foods

Table 1. Typical Dietary Fiber Content* of Frequently Consumed Foods per Portion and per 100 Grams

Food	Portion Size	Dietary Fiber (g/portion size)	Dietary Fiber (g/100 g)
Cereal (grain) and cereal products			
Bread: white	40 g (1 thick slice)	1.2	2.9
Bread: white, "with added fiber"	40 g (1 thick slice)	1.9	4.8
Bread: whole meal	40 g (1 thick slice)	2.8	7.0
Breakfast cereal, cornflakes, (un) fortified	20 g (3 Tbsp)	0.5	2.6
Breakfast cereal, crunchy, without nuts	30 g (2 Tbsp)	2.2	7.2
Breakfast cereal, crunchy, with nuts	30 g (2 Tbsp)	2.4	7.9
Breakfast cereal, bran flakes fortified	30 g (2 Tbsp)	4.0	13.4
Breakfast cereal, Weetabix	38 g (1 biscuit)	3.7	9.7
Breakfast cereal, oatmeal, unfortified	30 g (2 Tbsp)	2.3	7.8
Muesli, Swiss style, no added sugar, unfortified	30 g (2Tbsp)	2.6	8.5
Muesli, Swiss style, added sugar, unfortified	30 g (2Tbsp)	2.6	8.8
Rice, white, basmati, boiled	160 g (1 cup)	1.0	0.6
Rice, brown, wholegrain, boiled	160 g (1 cup)	1,9	1.2
Pasta, white, dried, boiled	160 g (1 cup)	4.0	2.5
Pasta, whole wheat, dried, boiled	160 g (1 cup)	10.6	4.2
Cakes and biscuits			
Cakes, sponge, homemade	60 g (1 slice)	0.7	1.1
Cake, fruit, home made	60 g (1 slice)	1.8	3.0
Biscuit, short, sweet	20 g (2)	0.4	2.2
Biscuit, digestive, plain	15 g (1)	0.6	3.8
Biscuit, digestive with oats, plain	10 g (1)	0.7	7.2
Biscuit, whole meal, homemade	10 g (1)	0.9	9.2
Oatcakes, plain, retail	10 g (1)	0.9	9.4
Fruit and vegetables			
Fruit, fresh			
Apple, flesh and skin	100 (1)	1.2	1.2
Banana, flesh only	80 g (1 small)	1.1	1.4
Grapes, average	60 g (12)	0.8	1.3
Nectarines, flesh and skin	90 g (1)	1.2	1.3
Oranges, flesh only	120 g (1 small)	1.4	1.2
Papaya, flesh only	150 g (1 small)	2.7	1.8
Pear, flesh only	100 g (1)	2.7	2.7
Plum, yellow, flesh and skin	55 g (1)	0.6	1.0 (NSP)
Fruit, dried			
Apple, dried	120 g (1 cup)	12	9.7 (NSP)
Apricots, dried	150 g (1 cup)	11.6	7.7 (NSP)
Dates, dried	30 g (2)	2.3	7.5
Fig, ready -to-eat, semi-dried	40 g (2)	4.0	10.0
Prunes, ready-to-eat, semi-dried	30 g (4)	1.6	5.2
Raisins, dried	30 g (1 Tbsp)	0.8	2.7
Vegetables			
Vegetables, raw			
Cucumber, raw, flesh and skin	40 g (6 slices)	0.3	0.7
Radishes, red	20 g (2)	0.2	1.1
Tomatoes, cherry, raw	15 g (1)	0.2	1.3
Vegetables, cooked			
Broccoli, green boiled	40 g (1 Tbsp)	1.1	2.8
Brussels sprouts, boiled	40 g (1 Tbsp)	1.3	3.2
Cabbage, green, boiled	40 g (1 Tbsp)	0.9	2.2
Carrots, old, boiled	40 g (1 Tbsp)	1.1	2.8
Beans, chick peas, canned re-heated, drained	40 g (1 Tbsp)	2.7	6.8
Beans, haricot, canned, re-heated, drained	40 g (1 Tbsp)	2.7	6.8
Beans, red kidney, canned in water, re-heated, drained	30 g (1 Tbsp)	2.0	6.8
Mushrooms, white, fried	40 g (4 medium)	0.4	1.0

(Continued)

Table 1. Typical Dietary Fiber Content* of Frequently Consumed Foods per Portion and per 100 Grams (*Continued*)

Food	Portion Size	Dietary Fiber (g/portion size)	Dietary Fiber (g/100 g)
Sweetcorn, canned in water, drained	30 g (1 Tbsp)	0.9	3.1
Sweet potato, flesh only, boiled	40 g (1Tbsp)	1.1	2.7
Potatoes			
Potatoes, new, boiled, with skin	60 g (1 small)	1.1	1.8
Potatoes, old, baked in jacket	100 g (1 small)	2.6	2.6
Nuts and seeds			
Nuts, mixed	10 g	0.6	6.2 (NSP)
Almond, toasted	13 g (6 whole)	1.4	10.9
Cashew nuts, plain	10 g (10 whole)	0.3	3.2 (NSP)
Peanuts, plain	10 g (10 whole)	0.6	6.2 (NSP)
Pecan nuts	9 g (3 whole)	0.4	4.7 (NSP)
Walnuts	20 g (6 halves)	0.7	3.5 (NSP)
Peanut butter, smooth	20 g (for 1 slice)	1.3	6.6
Plant-based drinks			
Drink, almond unsweetened	100 mL	0.3	0.3
Drink, almond with sugar plain/original	100 mL	0.2	0.2
Drink, oat with calcium and vitamins	100 mL	1.0	1.0
Milk soya (un)sweetened, fortified	100 mL	0.5	0.5
Miscellaneous			
Corn snacks	25g (1 small bag)	0.3	1.3
Popcorn, candied	20g (handful)	1.9	9.5
Potato crisps	25g (1 small bag)	1.1	4.4
Tortilla chips	25g (1 small bag)	1.5	5.9
Soup, lentil, canned	175 mL (1 cup)	2.1	1.2
Formulas			
Pediatric tube feed (1.0 kcal/mL; 1.5 kcal/mL; 2.0 kcal/mL) without fiber			0
Renal formula low in phosphate low in potassium			0
Pediatric tube feed 1.0 kcal/mL with fiber			0.73-1.1
Pediatric tube feed 1.5 kcal/mL with fiber			1.0-1.1
Pediatric sip feed without fiber (1.5 kcal/mL; 2.4 kcal/mL)			0
Pediatric sip feed with fiber (1.5 kcal/ mL)	-	-	1.1-1.9
Pediatric sip feed with fiber (2.4 kcal/ mL)			2.4

Tbsp, rounded tablespoon.
Data sourced and adapted from McCance and Widdowson's Composition of Foods Integrated Dataset (CoFID)[31]; Dutch Food Composition Database.[32]
*Non-starch (NSP) + resistant starch and lignin (A0AC Fiber).

containing intrinsic fiber. They may also contain other additives that are sources of phosphate, potassium and sodium which need to be reduced in the diet of individual children with CKD.

3. How is the dietary fiber intake assessed in children and adolescents?
   - 3.1 Obtain a diet history of a typical 24-hour period to determine baseline daily fiber intake and to identify the main dietary sources of fiber. (Level D; weak recommendation).
   - 3.2 A 3-day prospective diet diary may be used if more detailed information on fiber intake is required. (Level D; weak recommendation).

Rationale

Accurately assessing fiber intake in the healthy population is challenging as there is no "gold standard" approach to take. Different methods can be used to assess fiber intake, for example, food frequency questionnaire (FFQ), diet diary (DD), or diet history (DH), each with advantages and disadvantages. These (dis)advantages have been described in a previous guideline from the PRNT.[17] A prospective DD is preferred over FFQ for assessing fiber intake. Previous studies have demonstrated that DD and FFQ result in different estimates of fiber consumption, and the FFQ is less accurate: (1) FFQs are restricted to a short list of 100-200 items compared with the many thousands of foods in population food supplies; and (2) FFQs are retrospective

Table 2. The Suggested Dietary Intake for Fiber in Healthy Children Extrapolated From International Recommendations

Age (years)	SDI g/day	SDI g/1000 kcal
1-3	14-19	8.3-14
4-8	18-25	8.3-14
9-13	24-31 (M) 20-26 (F)	8.3-14
14-18	28-38 (M) 22-26 (F)	8.3-14.2

SDI, suggested dietary intake.

and there may be errors in assessing the frequency of consumption of foods and differences in perception of portion sizes.[36] In a study with 399 participants to assess the degree of agreement between dietary fiber intakes reported with an FFQ versus a 4-day food record, Hudson et al.[37] found that total dietary fiber intake was significantly higher with the food record than with the FFQ. More specifically, Stephen[2] and Day[38] found a greater variability in the assessment of fiber in fruits and vegetables with an FFQ in comparison to a 7-day DD.[2,38] Several other studies have proposed adapted FFQs to improve practical implementation and accuracy of fiber intake assessment.[37,39-41] Despite a multitude of different tools for assessing fiber intake, there are no studies justifying the use of an FFQ for the assessment of fiber intake in children. Further research is needed to determine the role of adapted FFQs in pediatric practice.

Fiber has not traditionally been considered when evaluating the kidney diet, unlike energy, protein, electrolytes, and minerals, which are considered prioritized constituents. To estimate fiber intake in clinical practice, we recommend the 24-hour DH. As described in previous PRNT guidelines,[17,18,42] the 24-hour DH is a detailed, retrospective dietary history technique consisting of questions about food and drinks consumed at meals and snacks through a typical 24-hour period. It is less time consuming than a DD and captures information on usual feeding habits. Be aware that not all fiber-containing food items may be included in a typical 24-hour DH. Dietary fiber content of foods may differ in food analysis programs and food composition tables due to regional variations on the definition of fiber and methods of analysis (Table S3). When detailed information about the diet (including data on nutrients other than fiber) is required, we recommend a 3-day DD.

4. What is the dietary fiber requirement for children and adolescents with chronic kidney disease?
   4.1 The fiber intake should approximate that of healthy children of the same chronological age. (Level D; weak recommendation)

Requirements for Healthy Children and Adolescents

Table S7 presents current national and international recommendations for fiber intake in healthy children. Since these recommendations for dietary adequacy have different definitions and methods in their derivation, the recommendations are not directly comparable.

As very little information is available about the effects of dietary fiber in childhood, the recommendations for daily fiber intake in these age-groups are extrapolated from recommendations for adults. The European Food Safety Authority concludes that a dietary fiber intake of 2 g per megajoule per day (this is equivalent to 8.3 g/1000 kcal/day) should be adequate for normal laxation in children based on the dietary fiber intake that is considered adequate for normal laxation in adults.[29] Australia and New Zealand base the adequate intake (AI) on the median intake in national dietary surveys in children.[43] The Institute of Medicine suggests an AI of 14 g fiber/1000 kcal/day (Table S7) based on the decreased risk of coronary heart disease with dietary fiber consumption of adults, and adjusted the AI for the caloric intake of children.[44,45] There is insufficient data to set a tolerable upper level of fiber intake for healthy adults and children. Some studies have shown that fiber-rich foods can alter the absorption of minerals, especially when phytate is present.[46,47]

Requirements for Children and Adolescents with Chronic Kidney Disease, on Dialysis, or After Kidney Transplantation

The Kidney Disease Outcome Quality Initiative (KDOQI) guideline, based on the Institute of Medicine recommendations, is the only kidney-specific

Table 3. Fiber Recommendations in Healthy Children by Food Choice per Day

	1-3 Years		4-8 Years		9-13 Years		14-18 Years	
Food Source	Portions (amount)	Fiber (g)	Portions (amount)	Fiber (g)	Portions (amount)	Fiber (g)	Portions (amount)	Fiber (g)
Bread, whole meal (slices)	2.5	7.0	4	11.2	4	11.2	5	14.0
Fruit	1.5	2.2	1.5	2.2	2	3.0	2	3.0
Potatoes	2	2.0	2	2.0	4	4.0	4	4.0
Vegetables	2	3.2	2	3.2	4	6.4	5	8.0
Fiber per day		14.4		18.6		24.6		29.0

Data sourced and adapted from McCance and Widdowson's Composition of Foods Integrated Dataset (CoFID).[31]

recommendation on fiber intake for children and suggests the same recommendations for fiber intake as for healthy children, that is, an AI of 14 g fiber/1000 kcal/day (Tables S3 and 7).[26,45] Like the KDOQI guideline, we suggest that children with CKD should have a similar fiber intake as their healthy peers (Table 2). To account for the different approaches to define AI and the analytic methods of derivation, we suggest a range for daily fiber intake for children with CDK. To overcome this, we use the term "suggested dietary intake" (SDI) for fiber as a range which includes both the lowest and highest recommendations for fiber intake reported in the literature (Table 2). The SDI for dietary fiber may be used for formulating dietary prescriptions and assessing the adequacy of dietary intake. Table 3 and Table S8 support the translation of the SDI for fiber into actual foods. Table 3 provides practical suggestions on achieving the fiber recommendations across pediatric age groups. Table S8 is a fiber swapping list, suggesting food choices that provide the same fiber content.

Prescribing adequate dietary fiber may be challenging in children with particular dietary restrictions; the previously published KDOQI guidelines do not provide any practical application of their fiber recommendations.[45] Therefore, in "Section 5", we provide recommendations on how adequate fiber intake should be achieved in children with CKD and variable degrees of kidney impairment.

5. Optimizing fiber intake in children and adolescents with chronic kidney disease
   - 5.1 Prioritize energy and protein requirements ahead of the fiber requirement, particularly in those with a poor appetite or those who require a higher energy intake. (Level D; weak recommendation).
   - 5.2 Select intrinsic fiber where possible, but a fiber supplement may be required to achieve the daily fiber requirement. (Level C; moderate recommendation).
   - 5.3 Encourage a variety of fiber-containing foods, selecting plant-based options where possible. (Level C; moderate recommendation).
   - 5.4 If hyperkalemia persists, after correction of non-dietary causes, adjust the diet in a stepwise approach aiming to maintain an adequate fiber intake: (Level D; weak recommendation).
     - Step 1: Limit foods rich in potassium additives.
     - Step 2: Limit potassium-rich foods with low fiber content and low nutritional value.
     - Step 3: Consider low potassium fiber-rich foods or fiber supplements (which have a low potassium content).
     - NOTE: In case of acute or severe hyperkalemia, temporarily limit potassium-rich foods irrespective of fiber content until serum potassium is controlled.
   - 5.5 Avoid fiber-rich foods that contain phosphate additives, but do not restrict fiber-rich foods containing natural sources of phosphate that have lower bioavailability. If a fiber supplement is needed, beware of possible phosphate additives. (Level C; moderate recommendation).
   - 5.6 For children requiring a fluid restriction, optimize the fiber intake based on tolerability and fluid allowance. (Level D; weak recommendation).
   - 5.7 In children receiving enteral or oral nutritional supplements, select a formula that contains fiber wherever possible. If a low fiber formula is used, supplemental fiber sources may be added. (Level D; weak recommendation).

Rationale

Importance of a Balanced and Diverse Diet

Achieving the recommended intake of fiber in children is important, but given the high risk of growth failure in children with CKD, energy and protein intake should be prioritized. Concerns have been raised that a high fiber diet in childhood may lead to a feeling of fullness, compromising energy intake.[48,49] For example, Rebello et al.[50] describes that oats can increase satiety by delaying gastric emptying in adult patients with CKD. However, data in pediatrics is limited and the association between appetite and fiber intake has not been confirmed by others.[51] Therefore, we do not recommend routinely minimizing fiber intake in children with a decreased appetite. We suggest, in these children, to follow-up on appetite and growth during the introduction of fiber and aim for the lower end of the SDI.

Where possible, we strongly suggest using intrinsic fiber sources rather than added fiber. As discussed in a recent review from the PRNT, the advantage of prescribing intrinsic fiber, derived from natural sources, is that the individual may derive additional benefits associated with dietary fiber.[1,4,52] Both O'Neil et al.[53] and Nicklas et al.[54] found that increasing the consumption of intrinsic fiber was associated with increased minerals and vitamin intake in children and adolescents, and reduced intake of added sugars, potassium and sodium.

Plant-based diets that typically have a high (intrinsic) fiber content, such as the Dietary Approaches to Stop Hypertension (DASH) diet, vegetarian diets, and the Mediterranean diet, should be encouraged.[55,56] The DASH diet, introduced in 1997, is rich in fruits and vegetables, has a reduced saturated and total fat content, and advises low-fat dairy foods. This provides a higher intake of potassium, calcium, and magnesium than a typical US diet (close to the 75th centile of US consumption) along with a high fiber and protein intake. The Mediterranean Diet, defined in 1960 and commonly consumed in Greece and Southern Italy, is rich in vegetable oils and fiber, and

Table 4. Potassium Content of Foods per Unit of Fiber

Food Source	<200 mg Potassium per 1 g fiber	>200 mg Potassium per 1 g fiber
High fiber sources (>6 g fiber per 100 g)	Crisp bread rye, red kidney beans dried boiled in unsalted water, flour wheat wholemeal, bread wholemeal average, breakfast cereal wheat biscuits Weetabix type, fortified, breakfast cereal Shredded Wheat type with fruit unfortified, porridge oats unfortified, apples dried, coconut fresh, muesli Swiss style unfortified, peanuts dry roasted, peanut butter smooth, dates dried flesh and skin, figs whole fruit dried, pistachio nuts roasted and salted	Apricots dried, spinach dried, mushroom dried, courgette dried
Moderate fiber sources (3-6 g fiber per 100 g)	Pasta wholewheat spaghetti dried boiled in unsalted water, cranberries, peas frozen boiled in unsalted water, red lentils split dried boiled in unsalted water, naan bread, bread brown average, flour wheat white plain soft, raspberries, blackberries, bread white French stick, bread Ciabatta, scones wholemeal homemade, kumquats, flour wheat white self-raising, breakfast cereal honey loops and hoops including honey and nut Cheerio's fortified, breadsticks plain, baked beans in tomato sauce canned, okra boiled, passion fruit, tempeh, broccoli steamed, blackcurrants, celeriac boiled, parsnip boiled, Brussels sprouts boiled, prunes, cashew nuts salted roasted, garlic, parsley	Potato chips homemade, Apricots dried stewed with sugar, Tomato puree, Potato crisps fried in sunflower oil, Raw cashew nuts (not roasted)
Low fiber sources (<3 g fiber per 100 g)	Noodles rice fine dried boiled in unsalted water, pasta white dried boiled in unsalted water, rice white basmati boiled in unsalted water, noodles egg fine dried boiled in unsalted water, custard powder, breakfast cereal, cornflakes crunchy/honey nut coated fortified, breakfast cereal cornflakes fortified, pear, croissants, rice brown or wholegrain boiled unsalted water, blueberries, strawberries, onions boiled or fried, bread white average, tapioca, pizza base, red cabbage boiled in unsalted water, old carrots boiled in water, passion fruit, doughnuts with jam, aubergine fried, broccoli boiled in salted water, citrus fruit soft/easy peelers, pineapple canned, pesto green, grapes	Tomato sauce homemade, celery raw, tomatoes cherry raw, asparagus steamed, lasagna homemade, old potatoes roasted and cooked, cucumber raw, dates, lychees, bananas, potato snacks Pringle-type fried in vegetable oil, American chocolate muffins, potato chips (all types), gherkins, Galia melon, raisins dried, plantain boiled, currants, bolognaise sauce homemade, yoghurt with fruit, rice pudding, red cabbage cooked with apples, fish products with batter
	<200 mg potassium per 100 g product	>200 mg potassium per 100 g product
No fiber sources (0 g fiber per 100 g or traces)	Marshmallows, mayonnaise, jelly made with water, sugar, gelatine, icing sugar, tea, butter salted and unsalted, coffee, margarine, cheese Mozzarella, honey, grape juice unsweetened, prawns standard purchased cooked, cheese Cheddar, cheese Gouda, crème fraiche fresh, cheese Brie, mussels, cheese Stilton, cheese feta, cheese Gruyere, cheese Camembert, cheese Ricotta, hen's egg poached or boiled, omelette homemade, milk whole semi-skimmed and skimmed, oil (all types)	Meat and meat products, fish and fish products

Be aware that bioavailability of potassium from natural foods is lower than from processed foods. Data sourced and adapted from McCance and Widdowson's Composition of Foods Integrated Dataset (CoFID).[31] Based on the 15-20 most popular food choices, for an extended list: see our practical guides.

low in saturated fat. Although there is no literature about children with kidney disease following vegan and vegetarian diets, the experience of adults with CKD following vegan/vegetarian diets is reassuring and no safety concerns are raised.[57,58]

In case intrinsic fiber sources are insufficient to achieve the daily fiber requirements, we suggest adding a fiber supplement. Caution is needed when prescribing a fiber supplement, as that are potential sources of phosphate, potassium, and sodium.

Optimizing Fiber Intake in Children with Hyperkalemia

As summarized in Table 1, fiber-rich foods are in general also high in potassium; and therefore, often omitted or restricted in traditional kidney diets.[59] This strategy may be unjustified as the bioavailability of potassium from fiber-rich foods is usually low.[60,61] For example, the bioavailability of potassium from unprocessed fruits and vegetables is less than 60%, while the bioavailability of potassium from animal foods, processed foods, and fruit juices is significantly higher.[56,60,62] Plant-based foods are not easily digested, the potassium that is present is predominantly intracellular, and a significant proportion of the potassium is excreted in the feces, hence the low bioavailability of potassium derived from plants. Recently, the practice of routinely omitting fruits and vegetables in adult patients with CKD has been questioned by several studies. These have suggested that increasing fiber (and thus also potassium) by increasing fruit and vegetable intake, or by implementing a 70% plant protein or vegetarian diet, does not result in higher serum potassium levels.[63-66] Similarly, El Amouri et al. could not find any correlation between serum potassium and dietary fiber intake in children with CKD.[59] More studies in pediatric populations addressing the safety of increasing fruits and vegetables in children with hyperkalemia are urgently needed.

In line with the PRNT CPR on the dietary management of potassium, we recommend that in case of hyperkalemia to primarily limit potassium-rich foods with (1) a high amount of potassium additives or (2) a low fiber content and low nutritional value (Table 4).[42] Caution should be exercised when limiting potassium-rich food sources with no fiber, as it is imperative that the nutrient content of other principal components, such as protein from meat, and milk (products) is not compromised (Table 4).

Optimizing Fiber Intake in Children With Hyperphosphatemia

For patients who require reduction of dietary phosphate, restriction of processed foods is preferred over foods with high nutritional value and high fiber content, such as whole grains, whole meal bread and legumes, as the bioavailability of phosphate additives in processed foods is close to 100%.[17,67] Plant-based sources of phosphate, such as grain products and legumes, are generally also high in fiber. However, the bioavailability of phosphate, bound to indigestible phytate in whole grains and legumes, is significantly lower than in processed foods. Moreover, the bioavailability of phosphate in plant-based sources depends on the preparation methods. Soaking can decrease the phosphate content in legumes and vegetables by about 50%.[68]

When hyperphosphatemia persists despite the omission of phosphate from processed food sources, we recommend limiting phosphate-rich sources with low fiber content. Nevertheless, caution is needed in this setting as these foods are often important sources of protein, such as meat and milkproducts. For the detailed management of phosphate in children with CKD, we refer to the PRNT CPR on calcium and phosphate.[17]

Optimizing Fiber Intake in Patients Requiring a Fluid Restriction

To achieve the beneficial effects of fiber on bowel health, an adequate fluid intake is required.[20,69-71] An analysis based on the National Health and Nutrition Examination Surveys, found that a low fluid consumption is a predictor of constipation among adult women.[72] Increasing fluid intake is especially effective in decreasing constipation in children who have a fluid intake that is lower than normal.[71]

Excessive intake of fiber may cause bloating, diarrhea, or intestinal obstruction when fluid intake is not sufficient.[73] Therefore, achieving an adequate fiber intake in children with a limited daily fluid intake, such as anuric patients on dialysis, is challenging. Currently, no studies are available on the minimum amount of fluid that minimizes side effects when prescribing an adequate fiber intake in children.[73] Therefore, we suggest that a lower fiber intake is acceptable in children with a fluid restriction. We recommend assessing the patient's intake of fiber and fluid, monitoring stooling habits by using the Bristol Stool Card.[74]

Optimizing Fiber Intake in Case of Enteral Tube Feeding

The European Society for Pediatric Gastroenterology Hepatology and Nutrition recommends that formulas with fiber are appropriate for most patients on enteral tube feeding.[75] Fiber and its fermentation products (short-chain fatty acids) have potential beneficial effects on intestinal physiology and the prevention of both diarrhea and constipation. Enteral formulas providing dietary fiber were shown to reduce diarrhea, with hydrolyzed guar gum and pectin being superior to soy polysaccharides. The use of a mixture of bulking and fermentable fiber has been suggested as a preferable approach.[75] There is no reason to deviate from this recommendation for children with CKD. Therefore, when available and applicable we recommend choosing enteral feeds with fiber. At the time of writing this article, there is no pediatric appropriate renal enteral feed available.

Table 5. Summary of Recommendations

	Category		Recommendation	Grade
1	What are dietary fibers?	1.1	Dietary fibers are carbohydrate polymers (defined as containing 3 or more monomeric units) that are not digested nor absorbed in the human intestine, or associated non-carbohydrate plant cell wall compounds.	Ungraded
		1.2	Carbohydrate polymers are naturally present in food (known as intrinsic fiber), or chemically/physically extracted, enzymatically modified or synthetically derived (known as added fiber). Carbohydrate polymers include three major groups: (i) non-starch polysaccharides (NSP), (ii) resistant oligosaccharides (RO), and (iii) resistant starch (RS). Non-carbohydrate plant cell wall (NPC) compounds such as lignins, chitins, and waxes are also included in the definition of fiber.	Ungraded
		1.3	Fibers (intrinsic and added) are required to have beneficial physiological effects in humans for inclusion in the definition.	Ungraded
		1.4	The official method of quantifying the amount of fiber in a food component as recommended by the Association of Official Analytical Chemists International (AOAC) has been followed in this CPR.	Ungraded
2	What are the main sources of fiber in the diet of children and adolescents?	2.1	The main sources of fiber in a child's diet include grain products, fruit, vegetables, potatoes, and legumes. The percentage of fiber contributed by different foods varies by geographical region and local eating patterns.	Ungraded
		2.2	Fiber added to processed foods contributes to the total daily fiber intake.	D (weak)
3	How is dietary fiber intake assessed?	3.1	Obtain a diet history of a typical 24-hour period to determine baseline daily fiber intake and to identify the main dietary sources of fiber.	D (weak)
		3.2	A 3-day prospective diet diary may be used if more detailed information on fiber intake is required.	D (weak)
4	What are the fiber requirements in children and adolescents with CKD?	4.1	The fiber intake should approximate that of healthy children of the same chronological age.	D (weak)
5	Optimizing fiber intake in diets of children and adolescents with CKD	5.1	Prioritize energy and protein requirements ahead of the fiber requirement, particularly in those with a poor appetite or those who require a higher energy intake.	D (weak)
		5.2	Select intrinsic fiber where possible, but a fiber supplement may be required to achieve the daily fiber requirement.	C (weak)
		5.3	Encourage a variety of fiber-containing foods, selecting plant-based options where possible.	C (moderate)
		5.4	If hyperkalemia persists, after correction of non-dietary causes, adjust the diet in a stepwise approach aiming to maintain an adequate fiber intake: (Level D; weak recommendation) - Step 1: Limit foods rich in potassium additives - Step 2: Limit potassium-rich foods with low fiber content and low nutritional value - Step 3: Consider low potassium fiber-rich foods or fiber supplements (which have a low potassium content). - Note: In case of acute or severe hyperkalemia, temporarily limit potassium-rich foods irrespective of fiber content until serum potassium is controlled.	D (weak)
		5.5	Avoid fiber-rich foods that contain phosphate additives, but do not restrict fiber-rich foods containing natural sources of phosphate that have lower bioavailability. If a fiber supplement is needed, beware of possible phosphate additives.	C (weak)
		5.6	For children requiring a fluid restriction, optimize the fiber intake based on tolerability and fluid allowance.	D (weak)
		5.7	In children receiving enteral or oral nutritional supplements, select a formula that contains fiber wherever possible. If a low fiber formula is used, supplemental fiber sources may be added.	D (weak)

CKD, chronic kidney disease.

When prescribing a feed made with several modular products, ensure that there is a source of fiber. Due to the lack of any scientific evidence regarding the choice of 1 fiber supplement above another, we suggest consideration of a blended feed made with fiber-rich fruits and vegetables to be given in combination with the modular feed to provide natural fiber if possible, taking due consideration of fluid and energy requirements.[76] Blended feeds of fruits and vegetables also provide the child with other benefits such as minerals, vitamins, and a more diversified intake.[1,77,78] In a prospective cohort study of 70 children (1-18 years) with different etiologies receiving blended tube feeding and commercial tube feeds, the participants or their caregivers reported greater ratings on the Pediatric Quality of Life Inventory Gastrointestinal Symptoms Scale (less vomiting, nausea, abdominal pain, reflux and diarrhea) in association with blended tube feeding.[79] There is no specific data on blended tube feeds for children with CKD; however, they should not be discouraged given the potential benefits. Proper and adequate teaching and risk assessment should be undertaken before initiating a blended feed to provide the natural fiber to modular feeds.[79-81] We refer the practitioner to local guidelines for blended feeds to minimize the risks of insufficient nutrient intake, contamination due to poor hygiene, or tube blockage.[81-84]

Results of the Delphi Survey

Twenty pediatric nephrologists and pediatric renal dietitians from 14 countries returned a completed survey. The names of all respondents are listed under “Acknowledgments” below. Of the 16 clinical practice recommendation statements overall, an average 90% consensus was achieved with a ’strongly agree’ or ’agree’ response. For all statements the stipulated minimum 70% consensus was reached. The Delphi responses reflected the wide variations in practice that can be expected in the absence of robust evidence, and none of the responses was based on published studies. Four statements received a “disagree” response, with the highest disagree rate to statement 5.2. On careful review by the Taskforce team, statement 5.2 on added fiber was adjusted as suggested by the respondents; clarification to the text and tables has been provided. None of the other statements required any change.

Summary of Recommendations

A summary of recommendations is provided in Table 5.

Research Recommendations

- Examining the differences in fiber intake quantification using different composition tables to identify innovative methods and technologies for improving the assessment of dietary fiber intake.
- Studying the safety of increasing fruit and vegetable consumption in children and adolescents with hyperkalemia with and without the use of potassium binding resins.
- Understanding the relation between fluid and fiber intake and the impact of fluid restriction on gastrointestinal tract symptoms.
- Exploring the impact of fiber intake on constipation, gastro-intestinal symptoms and on uremic toxin and systemic inflammation.

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Participants in the Delphi survey Dietitians: Beard, J, Oklahoma City, USA; Campana, C, Rome, Italy; Ezzat, M, Riyadh, Saudi Arabia; Grassi, M R, Milan Italy; Holmes, A, Liverpool, UK; Meenakshi, S, Chennai, India; Parnarauskienė, J, Vilnius, Lithuania; Steinmann, S, Hannover, Germany; Van der Vaerent, K, Leuven, Belgium; Winderlich, J, Melbourne, Australia. Pediatric Nephrologists: Bakkaloglu, S, Ankara, Turkey; Besouw, M, Groningen, The Netherlands; Edefonti, A, Milan, Italy; Govindan, S, Chennai, India; McCulloch, M, Cape Town, South Africa; Ma, A, Hong Kong; Oh, J, Hamburg, Germany; Reusz, G, Budapest, Hungary; Prytula, A, Belgium; Xu, H, Shanghai, China.

Supplementary Data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1053/j.jrn.2024.05.008.

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