

Hold the Salt?

FITS Raises Questions on Sodium/ Potassium Intakes of Toddlers

In adults, the prevalence of hypertension—and the accompanying higher risk for heart attacks and strokes—is associated with salt intake. It has been estimated, for example, that decreasing sodium intake of the adult population from 4,000 mg to 2,000 mg a day would lower average blood pressure by about 2 mm Hg, enough to save more than 10,000 lives a year from heart attacks and strokes.¹ Unfortunately, little is known about the impact of salt intake on blood pressure during childhood, or how childhood salt intake may affect blood pressure in adulthood.

The Feeding Infants and Toddlers Study (FITS) conducted in 2002 and published in 2004,^{2,3} showed that the usual mean intakes of most nutrients by 4–24-month-old children exceeded the Dietary Reference Intakes (DRIs) established recently by the Food and Nutrition Board, Institute of Medicine (IOM)^{4,8}—i.e., the usual mean intakes of most nutrients were adequate. However, DRIs of sodium, chloride and potassium were not available until after publication of the initial FITS data (2004). Now that this information is available,⁹ the intakes of these nutrients can also be compared to the DRIs.

This comparison shows that the usual mean intakes of sodium, chloride and potassium by 4–5 and 6–11-month-old infants, like the intake of most other



The usual mean intakes of sodium, chloride and potassium by 4-5 and 6-11-month-old infants were adequate. However, the usual mean intake of sodium and chloride by 12-24-month-old toddlers exceeded the Tolerable Upper Intake Level (UL) as well as the Adequate Intake (AI); in contrast, the usual mean potassium intake was considerably less than the AI.



nutrients by these age groups, also were adequate (i.e., exceeded the DRIs of these nutrients).¹⁰ However, the usual mean intake of sodium and chloride by 12-24-month-old toddlers exceeded the Tolerable Upper Intake Level (UL) as well as the Adequate Intake (AI) of these electrolytes; in contrast, the usual mean potassium intake was considerably less than the AI. The usual mean sodium and chloride intakes of 12-24-month-old toddlers were 64% higher than the AIs and the usual mean intakes of 58% of the toddlers were above the ULs, while the mean potassium intake of this age group was only 66% of the AI.

Sodium is the major extracellular cation of the body and chloride is the major extracellular anion. Both, therefore, are required for growth. The major concern with regard to a high sodium intake, as indicated above, is that it may increase blood pressure or, more important, may increase the likelihood of hypertension later in life.

Potassium, the major intracellular cation of the body, also is required for growth. It or its usual accompanying organic anion helps neutralize diet-induced acid (e.g., from protein). Even in the absence of hypokalemia (low blood levels of potassium), low potassium intake is associated with resorption of calcium from bone, calciuria, and formation of renal stones. It also reduces the effects of high sodium intakes on blood pressure. On the other hand, hyperkalemia (unusual even with a very high potassium intake) results in cardiac arrhythmias.

Under usual circumstances, homeostatic mechanisms maintain the plasma concentration of all electrolytes within a very narrow range. Nonetheless, it is desirable



Dietary Reference Intakes (DRIs)*

EAR (Estimated Average Requirement): the intake that meets the estimated nutrient need of 50 percent of the individuals in that group.

RDA (Recommended Dietary Allowance): the intake that meets the nutrient need of almost all (97 to 98 percent) individuals in that group.

AI (Adequate Intake): observed or experimentally derived intake by a defined population or subgroup that, in the judgment of the DRI Committee, appears to sustain a defined nutritional state, such as normal circulating nutrient values, growth, or other functional indicators of health.

UL (Upper Limit): the highest level of daily nutrient intake that is likely to pose no risk of adverse health effects to almost all individuals in the general population. As intake increases above the UL, the risk of adverse effects increases.

* Refers to daily intakes, averaged over time.

to review intakes of electrolytes, identify the food sources that contribute to any imbalances between intake and requirements, and offer suggestions to parents and physicians for dietary adjustments.

Sodium Chloride and Potassium— How Much are Children Getting?

Sodium

The usual mean daily intakes of sodium and chloride by 4-5 month old infants participating in FITS were roughly 60% higher than the AI (120 and 180 mg/d, respectively).^{*} The usual mean daily intakes of these nutrients by 6-11-month-old infants (370 and 570 mg/d, respectively) exceeded the AI by about 33%.

* The AI of sodium and potassium for 4-5-month-old infants are the intakes of these electrolytes by a breastfed infant receiving 780 ml/d of human milk containing 160 mg/L of sodium and 500 mg/L of potassium. Those for 6-11-month-old infants are the intakes from 600 ml human milk containing 160 mg/L of sodium and 500 mg/L of potassium. The AI of both for 12-24-month-old toddlers are extrapolated from adult AIs. The AI of chloride is assumed to be equimolar to that of sodium.⁹ This is because the usual dietary source of chloride is sodium chloride.

The usual mean daily intakes of potassium by both 4–5-month-old and 6–11-month-old infants were almost twice the AI. In contrast to the sodium and chloride intakes of 12–24-month-old toddlers, the usual mean daily potassium intake of this age group was only ~65% of the AI.

However, the 10th percentile of usual intake(s) of this age group was 50% of the AI while the 90th percentile of usual intake was 260% of the AI (the smaller number of 4–5-month-old infants, coupled with a skewed intake prevented calculation of percentiles of intake by this group).

By definition, the usual mean sodium (and chloride) intake(s) of infants participating in FITS were adequate. In contrast, the usual mean sodium (and chloride) intakes of the 12–24-month-old toddlers exceeded the AIs of 1–3-year-old toddlers (1,000 and 1,540 mg/d, respectively) by about 65%, and the UL (1,500 and 2,300 mg/d, respectively) by about 10%. Even the 10th percentile of usual intakes was above the AI and the mean usual intakes of 58% were above the UL. (See graph, “Electrolyte Intakes of Infants and Toddlers.”)

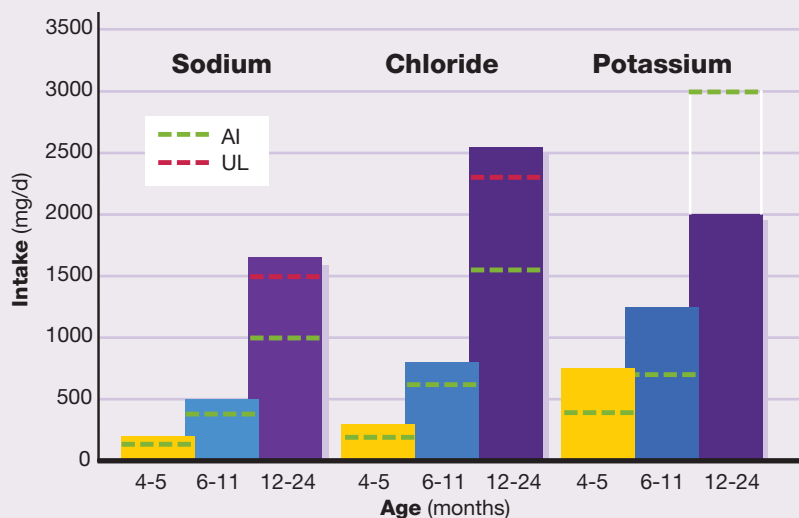
Potassium

The usual mean daily intakes of potassium by both 4–5-month-old and 6–11-month-old infants participating in FITS were almost twice the AI (400 and 700 mg/d). The 10th percentile of potassium intake by 6–11-month-old infants was about 15% higher than the AI and the 90th percentile of intake was 246% higher.

In contrast to the sodium and chloride intakes of 12–24-month-old toddlers, the usual mean daily potassium intake of this age group was only ~65% of the AI (AI = 3,000 mg/d).

Electrolyte Intakes of Infants and Toddlers

Sodium and chloride intakes of toddlers exceeded the Upper Limits (UL), while potassium intakes fell short of Adequate Intakes (AI).



Sources of Electrolyte Intakes

Sodium

As expected, milk accounted for over 90% of the sodium intake of 4–5-month-old infants, about half of the sodium intake of 6–11-month-old infants and close to 20% of the intake of 12–24-month-old toddlers. Other sources of the sodium intake of 4–5-month-old infants included grain products (cereals, breads, etc.) and vegetables but neither of these sources accounted for more than about 3% of total intake. Grain products, meats and other proteins and mixed dishes accounted for about a third of the sodium intakes of 6–11-month-old infants. Additional sources included vegetables (~7% of total intake), sweets (4.5% of total intake) and snacks (2% of total intake).**

Grain products, mixed dishes and meats and other proteins accounted for 62% of the sodium intake of 12–24-month-old toddlers. Vegetables, sweets and snacks each accounted for 6–7%. Snacks accounted for roughly three times as much of the sodium intake of 12–24-month-old toddlers as that of 6–11-month-old infants. (See graph, “Food Sources of Sodium and Potassium Intakes.”)

** Sodium intakes are intakes from whole foods, not the separate components. The intakes include sodium used in preparation but not sodium added “at the table.”



Interestingly, the sodium and potassium intake pattern of 12–24-month-old toddlers changed very little after about 12 months of age. This suggests that these patterns are established between 6 and 12 months of age.



It is important to note that the usual mean intakes of sodium (and chloride) at the various ages include the salt used in food preparation, but not salt that may have been added to prepared foods. Thus, if salt is added to these foods, the usual mean intake(s) of sodium (chloride) will be much higher. For example, the previously reported FITS data indicated that French fried potatoes were the most common vegetable consumed by 15–18-month-old toddlers. It is interesting to note that one small serving of the popular brands of fast food French fries contains from 135–530 mg of sodium (depending upon the brand)—13.5 to 55% of the established AI of sodium for toddlers.¹¹ Any salt that is added after purchase is additional.

Potassium

Milk accounted for a somewhat lower percentage of the potassium intake of 4–5-month-old infants than it did for sodium intake (~80% vs. ~90%) but, not surprisingly, was the major source of potassium intake of this age group. Other sources included grain products (~7% of total), fruits (4.5% of total), fruit juices (2% of total) and vegetables (4% of total).

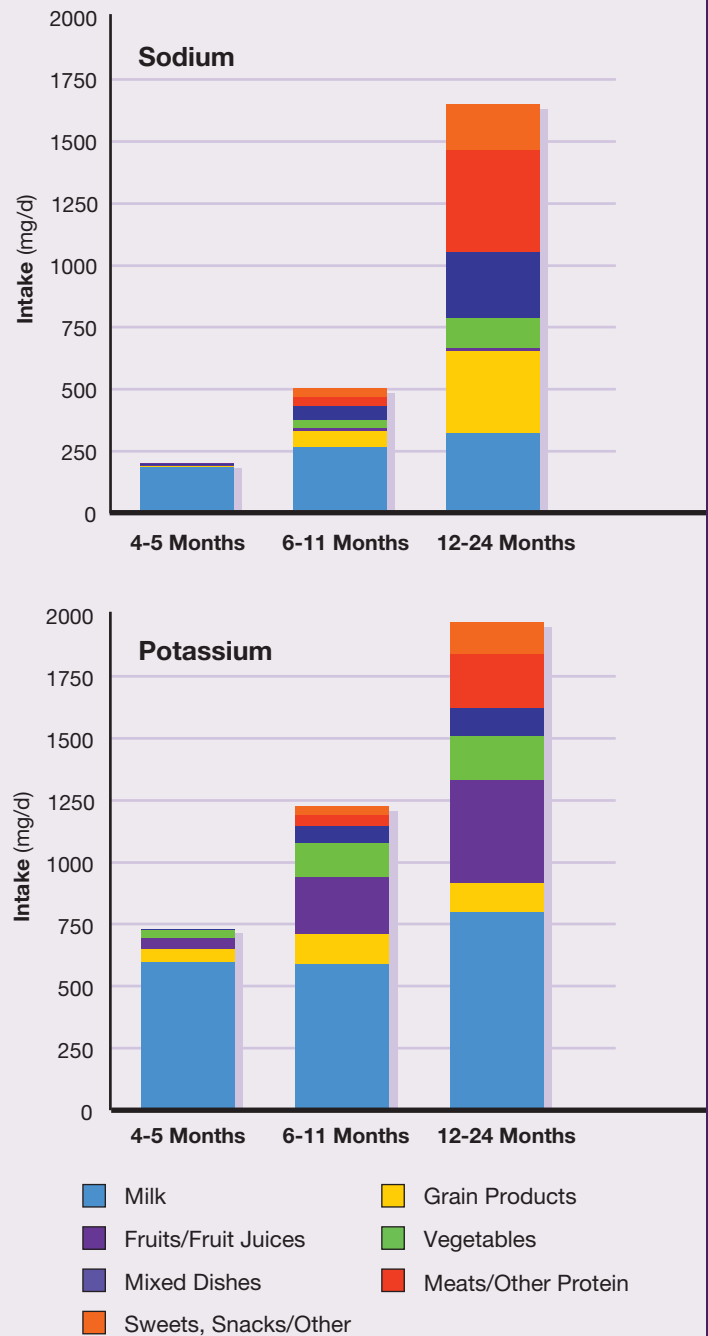
Milk contributed slightly less than 50% of the potassium intake of 6–11-month-old infants; fruits (13% of total), fruit juices (6% of total), vegetables (11% of total), grain products (10% of total) and mixed dishes (5.5% of total) were the major non-milk sources.

Milk also was the major source of the potassium intake of 12–24-month-old children (40% of total), but fruits and fruit juices accounted for over 20% of the total potassium intake of this age group, meats and other proteins for 11%, vegetables for 9%, grain products for 6%, mixed dishes for 6%, sweets for 4% and snacks for 2.5%.

Interestingly, the intake pattern of 12–24-month-old toddlers changed very little after about 12 months of age (See graph, “Changes in Intakes from Different Food Sources,” page 22.) This suggests that these patterns are established between 6 and 12 months of age.

Food Sources of Sodium and Potassium Intakes

As children grow, food sources of sodium and potassium change significantly. Snacks accounted for roughly three times as much of the sodium intake of 12-24-month-old toddlers as that of 6-11-month-old infants.



For the most part, the contributions of the different milk products to the total sodium and potassium intakes of infants and toddlers reflect current feeding advice. Of note are the facts that cow milk did not account for a significant intake of sodium and potassium until after 12 months of age and that only about 25% of cow milk intake was low-fat rather than whole milk, as usually advised.

Comparing Different Milk Products

As recommended, breast milk and infant formulas were the only milk products contributing to the sodium intake of 4–5-month-old as well as 6–11-month-old infants. However, the percent from breast milk was ~50% lower at 6–11-months than at 4–5 months, and the percent from formula about 25% higher. In contrast, but as expected, breast milk and formula accounted for very little of the sodium intake from milk products after 12 months of age. Of the 90% of total sodium intake from cow milk at this age, about 25% was from reduced fat milk rather than whole milk (See graph, “Contribution of Different Milk Products”).

Contributions of the different milk products to the total potassium intakes of 4–5, 6–11 and 12–14-month-old infants and toddlers, of course, were similar to the contributions of these products to total sodium intakes. Breast milk and formula were by far the major milk sources of potassium at 4–5 months of age (40% and 60% from breast milk and formulas, respectively) and cow milk was the primary contributor (90%) at 12–24-months-of-age.

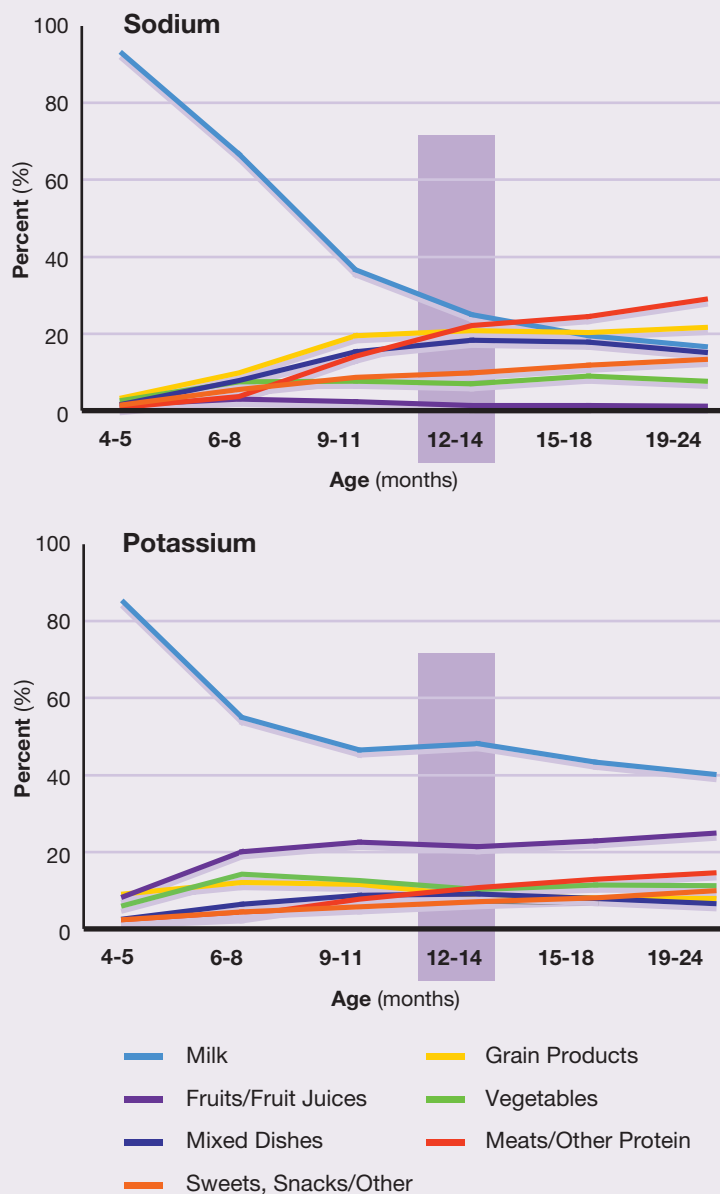
For the most part, the contributions of the different milk products to the total sodium and potassium intakes of infants and toddlers reflect current feeding advice.^{12,13} An exception concerns the contribution from breast milk, which is lower than desired for all age groups but particularly for both of the younger groups. Of note are the facts that cow milk did not account for a significant intake of sodium and potassium until after 12 months of age and that only about 25% of cow milk intake was low-fat rather than whole milk, as usually advised.^{14,15}

Evidence of Excess Sodium

The usual mean sodium (and chloride) intakes of 4–5-month-old, 6–11-month-old and 12–24-month-old infants and toddlers who participated in FITS exceeded the AIs of sodium for the respective age groups by approximately 60%, 33% and 64%. By definition, these intakes raise no concerns about the adequacy of sodium intake. However, the usual mean intakes of the 12–24-month-old toddlers also exceeded the UL and this is a reason for concern.

Changes in Intakes from Different Food Sources

Patterns of eating and food sources seem set at 12 months of age. Little change occurs after this age.



The usual mean potassium intake of 4–5-month-old and 6–11-month-old infants also exceeded the AI for these age groups (by 75% and 80%, respectively); hence, these intakes also do not raise concerns about adequacy. However, the usual mean potassium intake of 12–24-month-old toddlers was low—only 66% of the AI of potassium for 1–3-year-old children.

As noted above, there is no conclusive evidence that a high sodium intake during childhood is associated with development of hypertension. Nevertheless, studies in adults show a continuous increase in blood pressure with increasing sodium intake, starting at quite low intakes.



The DRIs of 4–5-month-old infants are based on the average intakes of exclusively breast-fed infants (780 ml/d). Those of 6–11-month-old infants are based on the average intakes of breast-fed infants of this age plus the average intakes of complementary foods by this age group. The DRIs for 1–3-year-old toddlers are extrapolated from adult values. Assuming that these are appropriate, the most likely reason for the observed intakes of these nutrients is either that the intake of formula and/or breast milk is excessive or that the reported intakes are falsely high.

Availability of weight data would help in determining which of these possible explanations is most likely but, unfortunately, available weight data are self-reported and, hence, of questionable accuracy. In this regard, the mean energy intakes of 4–5-month-old infants, 7–12-month-old infants and 12–24-month-old toddlers, respectively, were 10%, 23% and 31% higher than the estimated energy requirement (EER) of these age groups.¹⁶ This supports the likelihood of excessive breast milk and/or formula intake. However, over-reporting of intakes by parents of young infants and children is a recognized problem.

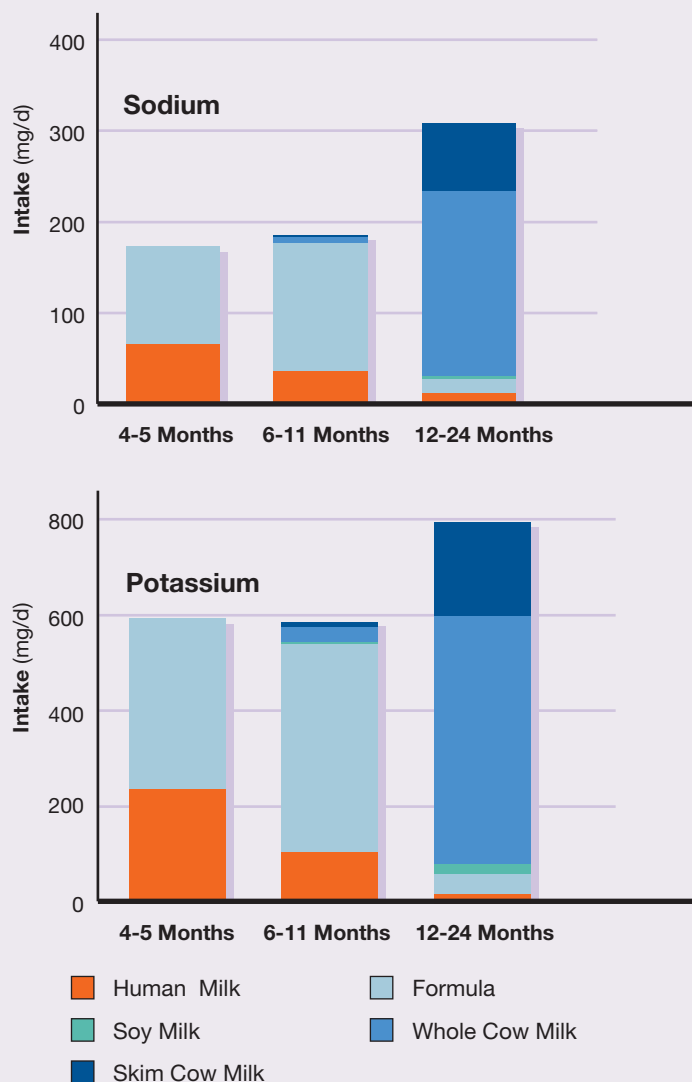
Should We Be Concerned?

As noted above, there is no conclusive evidence that a high sodium intake during childhood is associated with development of hypertension. Nevertheless, studies in adults show a continuous increase in blood pressure with increasing sodium intake, starting at quite low intakes.¹⁷ Another concern, for which there is even less data, is that high sodium intakes in infancy may enhance the likelihood of hypertension in adulthood. The major concern about a low potassium intake is that it will tax the homeostatic mechanisms involved in maintaining a normal acid-base status—e.g., resorption of bone to neutralize a high dietary acid load.

The plasma concentrations of both sodium and potassium are maintained within very narrow limits. Thus, unless losses (e.g., excessive sweating, diarrhea and/or vomiting) or intakes are quite high, plasma concentrations of both remain within these very narrow limits. However, this exquisite control under usual circumstances does not indicate that

Contribution of Different Milk Products

For the most part, the contributions of the different milk products to the total sodium and potassium intakes of infants and toddlers reflect current feeding advice. An exception concerns the contribution from breast milk, which is lower than desired for all age groups but particularly for both of the younger groups.



intakes should not be a concern. Certainly, intakes close to recommended levels are less likely to tax the homeostatic mechanisms for maintaining a narrow range of plasma sodium and potassium concentrations.

In addressing the issue of whether current intakes of sodium (and chloride) and potassium are excessive

The sodium and potassium intakes of the 12–24-month-old age group are problematic. Since even the 10th percentile of usual sodium intake by 12–24-month-old toddlers is somewhat higher than the AI and the sodium intake of 58% of this age group is higher than the UL, the sodium intake of this age group almost certainly is excessive.

or inadequate, it is unlikely that the intakes of 4–5-month-old and 6–11-month-old infants are problematic. At any rate, unless the human milk and/or formula intake is excessive relative to the intakes on which the DRIs are based, which is likely, little can be done other than advising a lower intake of breast milk and/or formula. However, it is difficult to justify such advice until more is known about the actual breast milk and formula intakes of this age group.

In contrast, the sodium and potassium intakes of the 12–24-month-old age group are problematic. Since even the 10th percentile of usual sodium intake by 12–24-month-old toddlers is somewhat higher than the AI and the sodium intake of 58% of this age group is higher than the UL, the sodium intake of this age group almost certainly is excessive. In contrast, the usual mean intake of potassium by this group is only about two-thirds of the DRI (AI), suggesting some level of inadequacy of potassium intake by this group.

Recommendations for Balancing Intake*

Foods other than milk contribute significantly to the sodium intake of 6–11-month-old infants and, particularly, 12–24-month-old toddlers. Since the concentration of sodium is usually lower in commercially prepared and home-prepared complementary foods to which salt has not been added, use of these foods in lieu of prepared foods such as processed meat will help reduce sodium intake. For example, a one-ounce serving of commercially prepared infant turkey provides 13 mg of sodium and 45 mg of potassium whereas a one-ounce serving of processed turkey breast luncheon meat provides 335 mg of sodium and 39 mg of potassium.

Other processed meats (e.g., ham, cold cuts) are high in both sodium and potassium. Peanut butter, particularly if unsalted, is high in potassium and low in sodium, but may not be appropriate for younger toddlers or for any toddler with a family history of food allergies. Most fruits have virtually no sodium and are high in potassium. Vegetables also are relatively low in sodium and high in potassium. So, increasing intake of fruits and vegetables by children over a year of age, as frequently advocated, will provide potassium without excessive sodium. Note, however, that this is not true for such foods as French fried potatoes!

It should be noted that the increase in sodium intake between 6 and 12 months of age coincides with the introduction of table foods and whole or low-fat cow milk. Introduction of table foods usually begins at about nine months of age and, by 12 months of age, most children are eating table food almost exclusively. Since the sodium concentration of cow milk (80 mg/100 kcal) is more than three-fold higher than the sodium concentration of human milk and formula, transition from human milk or formula to cow milk also results in a marked increase in sodium intake. The major drawback to delaying introduction of cow milk and continuing formula well into the second year of life is the much higher cost of formula. Thus, considering the limited evidence that the current sodium intake of most toddlers is problem-

* FITS data was collected on infants and toddlers living in the U.S., and thus the recommendations above are based on the needs of U.S. children.



Obviously, parents should discourage the addition of salt at the table and, to set a good example, limit the amount of salt added to their food. Finally, although snacks are not a major source of sodium intake, the intake of salty snacks obviously should be limited.



atical, one is reluctant to advise continuation of formula beyond about 12 months of age.

Delaying introduction of table foods also is questionable. These foods not only provide nutrients but also serve an important developmental role. On the other hand, since the major source of sodium in table foods is the salt that is added in cooking, parents can be advised to limit the salt used when preparing foods for infants. They should also be advised to study labels of ready-to-eat foods such as macaroni and cheese, soups, packaged dinners which can be “hidden” sources of salt intake. Obviously, parents should discourage the addition of salt at the table and, to set a good example, limit the amount of salt added to their food. In the absence of added salt, the sodium content of home-prepared foods should be roughly the same as that of commercially prepared infant and toddler foods. Finally, although snacks are not a major source of sodium intake, the intake of salty snacks obviously should be limited. •

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