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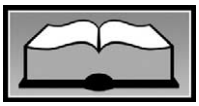

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Current Electrolyte Intakes of Infants and Toddlers

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ABSTRACT

Objective To determine how sodium, chloride, and potassium intakes of today's infants and toddlers compare with the Dietary Reference Intakes (DRIs) of these nutrients established recently by the Food and Nutrition Board of the Institute of Medicine.

Study design Population estimates of usual intake distributions of sodium, chloride (assumed to be equamolar to sodium), and potassium of 4- to 5-, 6- to 11-, and 12- to 24-month-old infants and toddlers were calculated and compared with DRIs of these nutrients by 0- to 6-month-old, 7- to 12-month-old, and 1- to 3-year-old children.

Subjects Infants and toddlers (n=3,022) who participated in the 2002 Feeding Infants and Toddlers Study.

Statistical analyses Means and distributions (percentiles) of the usual intakes of sodium, chloride, and potassium were calculated using Institute of Medicine-recommended procedures and compared with the DRIs (ie, Adequate Intake [AI] and tolerable upper intake level [UL]).

Results Mean sodium and chloride intakes of 4- to 5-month-old infants (188 mg/day and 290 mg/day, respectively) were 57% greater than the AIs (120 mg/day and 180 mg/day) and mean potassium intake (730 mg/day) was 83% higher than the AI (400 mg/day). Mean sodium, chloride, and potassium intakes of 6- to 11-month-old infants were 493 mg/day, 761 mg/day, and 1,225 mg/day, respectively—33%, 33%, and 75% higher than the AIs of these nutrients for this age group (sodium, 370 mg/day; chloride, 570 mg/day; potassium, 700 mg/day). Even the 10th percentile of potassium intake of this age group was greater than the AI. The usual mean sodium and chloride intakes of 12- to 24-month-old toddlers (1,638 mg/day and 2,528 mg/day, respectively) were 64% higher than the AIs (1,000 mg/day and 1,540 mg/day, respectively) and the usual mean sodium and chloride intakes of 58% of this age group were above the ULs. In contrast, mean potassium intake of 12- to 24-month-old toddlers (1,971 mg/day) was only 66% of the AI (3,000 mg/day). At all ages, sources of sodium, chloride, and potassium intakes reflected current feeding guidelines, primarily human milk and formula prior to 6 months of age and primarily cow's milk and table foods after 1 year of age.

Conclusions Mean sodium and chloride intakes of infants and toddlers who participated in the 2002 Feeding Infants and Toddlers Study exceeded the recently established AIs of these nutrients and the mean intake of 58% of toddlers exceeded the ULs. Mean potassium intake of infants also exceeded the AI of potassium, but the mean potassium intake of toddlers was only 66% of the AI. Whether current intakes of sodium, chloride, and potassium by infants and toddlers are problematical is not clear. Nonetheless, it seems desirable to bring these intakes closer to AIs. This can be accomplished by continuing breast- or formula-feeding and delaying the introduction of cow's milk; limiting the amount of salt added to home-prepared foods; limiting the intake of high-sodium foods, such as processed meats and salty snacks; and increasing the intake of fruits (high potassium and low sodium content) and vegetables (moderate potassium and sodium content).

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A recent study of the dietary intakes of more than 3,000 children from 4 to 24 months of age (the Feeding Infants and Toddlers Study [FITS]) provides considerable information concerning the current nutrient intakes of US infants and young children (1). These nutrient intakes, in turn, can be compared to the Dietary

Reference Intakes (DRIs) for nutrients established by the Food and Nutrition Board of the Institute of Medicine (2-7). This comparison was done for most nutrients and showed that the usual mean nutrient intakes of infants less than 12 months of age exceeded the Adequate Intakes (AIs) of all nutrients (8). For most nutrients, usual intakes of 12- to 24-month-old toddlers also were adequate. A possible exception concerns intakes of sodium, chloride, and potassium, the DRIs of which were not available until after publication of the initial FITS findings (1,8).

Lack of information concerning the extent to which the current electrolyte intakes of infants and toddlers are less than or greater than the DRIs for these nutrients is unfortunate. In part, this is because the current sodium intake of adults is higher than the previous safe and adequate intake and the current potassium intake is less. Moreover, a survey of nutrient intakes during the first year of life conducted about 20 years ago (9) indicated that sodium intake increased from about 200 mg/day between 2 and 5 months of age (safe and adequate intake for this age group=115 to 350 mg/day) to >1,000 mg/day at 12 months of age (safe and adequate intake for this age group=200 to 750 mg/day).

The objective of the study reported here was to compare current intakes of sodium, chloride, and potassium by 4- to 24-month-old children to the DRIs of these nutrients and also to compare current intakes of sodium and chloride to the intakes of these nutrients reported approximately 2 decades ago (9). In addition, the dietary sources of these nutrients, particularly those that exceed the tolerable upper intake level (UL), are identified in order to provide guidance to medical and nutritional professionals as well as parents or other caregivers concerning dietary changes that will bring electrolyte intakes of infants and toddlers closer to the DRIs.

METHODS

Sodium, chloride, and potassium intakes of 4- to 5-month-old, 6- to 11-month-old, and 12- to 24-month-old infants and toddlers who participated in the 2002 FITS were calculated using 24-hour dietary recall data collected with the Nutrition Data System for Research (version 4.03, 2001, University of Minnesota Nutrition Coordinating Center, Minneapolis). Calculated intakes included contributions from foods and dietary supplements, but did not include any salt that may have been added to the foods at the time of consumption (1,10).

Participants in FITS included infants and toddlers between 4 and 24 months of age. They were selected randomly from a national sample to participate in a cross-sectional telephone survey of infants' and toddlers' food intakes based on 24-hour dietary recalls by parents or other primary caregivers. Recruitment of subjects, sampling frame, data collection process, and nutrient analysis procedures have been described (1,8,10). All data collection instruments and procedures were reviewed and approved by Mathematica Policy Research, Inc's (Washington, DC) institutional review board compliance officer and quality assurance system. All participants received written information concerning the study, understood that participating in the study was voluntary, and were assured of the confidentiality of data. Consent from each respondent was obtained before proceeding with the study interviews.

The food grouping scheme developed for FITS allowed flexibility in reporting foods and food groups with various levels of detail. As described previously (11), individual foods and beverages reported in the 24-hour recall were assigned to major and minor food groups similar to those used in the most recent Continuing Survey of Food Intakes by Individuals (12). The percentage of infants and toddlers who consumed any amount of a given food or beverage on the recall day also was tabulated for 4- to 5-month-old, 6- to 8-month-old, 9- to 11-month-old, 12- to 14-month-old, 15- to 18-month-old, and 19- to 24-month-old infants and toddlers (and for collapsed age groups of 4- to 5-month-old, 6- to 11-month-old, and 12- to 24-month-old infants and toddlers) as was the average percentage of daily intake of sodium and potassium from the major food groups (milk and milk products; grain products; fruits; fruit juice; vegetables; meat and other protein sources; mixed dishes; sweets, desserts, and sweetened beverages; snacks; and other foods and supplements). To produce these estimates, percentages of the daily total nutrient intake at the person-level were calculated, sample weights were applied, and the average daily nutrient intake from various food groups (totaling 100% of the daily intake) for the population was calculated.

Lack of information concerning the extent to which the current electrolyte intakes of infants and toddlers are less than or greater than the DRIs for these nutrients is unfortunate.

Foods were further selected from each food category based on foods commonly eaten by infants and toddlers. Sodium and potassium contents of both commercial and home-prepared infant foods were based on data in the Nutrition Data System for Research database. The composition of various milks also was calculated using the Nutrition Data System for Research database. Chloride intake was assumed to be equimolar to the intake of sodium.

Statistical Analysis

Sample weights were calculated to account for nonresponse and to weight the sample to known population demographic characteristics. Statistical Analysis Software (version 8.2, 2001, SAS Institute, Inc, Cary, NC) was used to create analytic variables. SUDAAN (version 9.0, 2004, Research Triangle Institute, Research Triangle Park, NC) was used to make estimates, using the appropriate sample weights and accounting for the complex design. The personal computer version of the Software of Intake Distribution Estimation (version 1.02, 2001, Iowa State University, Ames) was used to account for day-to-day variation in nutrient intake and methods recom-

Table 1. Usual intake of sodium, chloride,[a] and potassium by 4- to 5-month-old infants and AI[b] of each nutrient for 0- to 6-month-old infants

Nutrient	Mean intake (mg/day)	AI[b] (mg/day)
Sodium	188	120
Chloride	290	180
Potassium	730	400

[a]Intake of chloride assumed to be equimolar to that of sodium.
[b]AI=Adequate Intake.

mended by the Institute of Medicine (13) were used to assess the usual nutrient intakes of infants and toddlers.

Estimates of the percentiles of the usual intake distributions of sodium, chloride (assumed to be equamolar to sodium), and potassium were calculated and compared with the AI of each nutrient. Population groups with a mean intake at or above the AI can be assumed to have an adequate amount of that nutrient (13). The proportion of toddlers whose intake of sodium was above the UL (ie, excessive) was also calculated. The AI and UL for sodium intake of toddlers was extrapolated from the adult AI and UL, based on relative energy intakes of children of this age vs adults (7). ULs for sodium intake of infants and potassium intake of both infants and toddlers could not be established.

RESULTS

As shown in Table 1, the mean usual intakes of sodium, chloride, and potassium by 4- to 5-month-old infants participating in FITS exceeded the AI. Mean intakes of sodium and chloride were roughly 60% higher than the AI, while mean intake of potassium was almost twice the AI of this electrolyte. The AIs of sodium and potassium are the intakes of these electrolytes by a breastfed infant receiving 780 mL/day of human milk containing 160 mg/L of sodium and 500 mg/L of potassium. Although the chloride intake of the breastfed infant is higher, the AI of this electrolyte is assumed to be equimolar to that of sodium (7). This is because the usual dietary source of chloride is sodium chloride.

Table 2 shows the mean usual intakes of sodium, chloride, and potassium by 6- to 11-month-old infants as well as the median intakes and the 10th, 25th, 75th, and 90th percentiles of usual intake. Table 2 also shows the AI of these nutrients for the 6- to 11-month-old infant, ie, the amounts of each in 600 mL of human milk with a sodium concentration of 160 mg/L and a potassium concentration of 500 mg/L plus the contents of each in the average complementary food intake of the 6- to 11-month-old infant (7). As for the 4- to 5-month-old, the AI of chloride is assumed to be equimolar to that of sodium.

Although median intake of sodium and chloride by 6- to 11-month-old infants participating in FITS was close to the AI, mean intakes of these electrolytes as well as potassium exceeded the AI. Sodium (and chloride) intake ranged from about 50% of the AI at the 10th percentile of usual intake to 260% at the 90th percentile. The 10th percentile of potassium intake was about 15% higher than the AI, the median intake was about 67% higher, the mean usual intake was about 75% higher, and the 90th percentile of intake was 246% higher.

Table 3 shows the mean usual intakes of sodium, chloride, and potassium by 12- to 24-month-old tod-

Table 2. Usual intakes of sodium, chloride,[a] and potassium by 6- to 11-month-old infants and AI[b] of each nutrient for 7- to 12-month-old infants

	Usual Intake Percentiles (mg/day)						
Nutrient	10th	25th	Median	Mean	75th	90th	AI[b] (mg/day)
Sodium	179	241	364	493	599	967	370
Chloride	276	372	562	761	925	1,493	570
Potassium	791	959	1,170	1,225	1,425	1,720	700

[a]Intake of chloride assumed to be equimolar to that of sodium.
[b]AI=Adequate Intake.

Table 3. Usual intake of sodium, chloride,[a] and potassium by 12- to 24-month-old toddlers and AI[b] and UL[c] of each nutrient for 1- to 3-year-old children

	Usual Intake Percentiles (mg/day)							
Nutrient	10th	25th	Median	Mean	75th	90th	AI[b] (mg/day)	UL[c] (mg/day)
Sodium	1,051	1,289	1,588	1,638	1,931	2,288	1,000	1,500
Chloride	1,622	1,990	2,451	2,528	2,980	3,531	1,540	2,300
Potassium	1,337	1,604	1,933	1,971	2,297	2,654	3,000	—

[a]Intake of chloride assumed to be equimolar to that of sodium.
[b]AI=Adequate Intake.
[c]UL=tolerable upper intake level.

Table 4. Sources of sodium intake of 4- to 5-, 6- to 11-, and 12- to 24-month-old children

Food group	4-5 Months (%) (n=624)	6-11 Months (%) (n=1,395)	12-24 Months (%) (n=1,003)
Milk	92.2	51.2	18.9
Grain	2.6	13.9	20.3
Fruits	0.3	1.1	0.3
Fruit juice	0.5	0.9	0.4
Vegetables	2.0	6.9	7.3
Meats/other protein	0.1	8.1	25.2
Mixed dishes	1.0	10.8	16.1
Sweets	0.3	4.5	5.6
Supplements	0.6	0.6	0.3
Snacks/other	0.5	2.0	5.7

Table 5. Sources of potassium intake of 4- to 5-, 6- to 7-, and 12- to 24-month-old children

Food group	4-5 Months (%) (n=624)	6-11 Months (%) (n=1,395)	12-24 Months (%) (n=1,003)
Milk	81.3	47.9	40.3
Grain	7.0	9.7	6.1
Fruits	4.5	13.0	10.9
Fruit juice	1.9	5.9	10.1
Vegetables	4.1	11.2	9.0
Meats/other protein	0.1	3.5	11.0
Mixed dishes	0.6	5.5	5.6
Sweets	0.4	2.5	4.2
Supplements	0.2	0.3	0.3
Snacks/other	0.1	0.4	2.4

dlers along with the AI of these electrolytes for the 1- to 3-year-old child and the UL for sodium and chloride; a UL for potassium could not be established. Usual sodium and chloride intakes of this age group were quite high. Mean usual intakes exceeded the AI of 1- to 3-year-old toddlers by about 65% and the UL 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.

In contrast to the sodium and chloride intakes, the usual mean potassium intake of 12- to 24-month-old toddlers was considerably less than the AI. Both the median and mean intakes were ~65% of the AI. This intake pattern is similar to that of adults, ie, adequate to excessive sodium intake and low potassium intake.

Table 4 shows the sources of the sodium and potassium intakes of 4- to 5-month-old, 6- to 11-month-old, and 12- to 24-month-old infants and children. Milk accounted for almost all the sodium intake of 4- to 5-month-old infants, whereas it accounted for only about half of the sodium intake of 6- to 11-month-old infants and less than 20% of the sodium intake of 12- to 24-month-old children. Additional sources of the sodium intake of 4- to 5-month-old infants were primarily grain products (cereals, breads, etc) and vegetables (<5% of total). Grain products, mixed dishes, meats and other proteins, vegetables, sweets, and snacks were the primary nonmilk sources of the sodium intake of 6- to 11-month-old infants.

Changes in sources of sodium intake between 4 to 5 months of age and 6 to 11 months of age continued after 12 months of age, when meats and other proteins and grain products accounted for close to half of the sodium intake. Other sources of sodium intake of this age group included milk, mixed dishes, vegetables, sweets, and snacks. Snacks accounted for roughly three times as much of the sodium intake of 12- to 24-month-old toddlers as that of 6- to 11-month-old infants.

As shown in Table 5, milk accounted for a somewhat lower percentage of the potassium intake of 4- to 5-month-old infants than it did for sodium intake but was, by far, the major source of potassium intake of this age group. Other sources included grain products, fruits, fruit juices, and vegetables. Milk contributed slightly less than 50% of the potassium intake of 6- to 11-month-old infants; fruits, fruit juices, vegetables, grains, and mixed dishes were the major nonmilk sources. Milk also was the major source of the potassium intake of 12- to 24-month-old children, but over 20% of the total potassium intake of this age group came from fruits and fruit juices. Other major sources included meats and other proteins, vegetables, grain products, mixed dishes, and sweets. The largest percentage change in source of potassium intake between 6 to 11 months of age and 12 to 24 months of age was the intake from snacks, which increased about sixfold.

Table 6. Contribution of different food sources to mean sodium intakes (mg/day) of 4- to 5-, 6- to 11-, and 12- to 24-month-old infants and toddlers[a]

Food group	4-5 Months (n=624)	6-11 Months (n=1,395)	12-24 Months (n=1,003)
Milk	173	252	310
Grain products	5	69	333
Fruits/fruit juices	2	10	12
Vegetables	4	34	120
Meats/other protein	—	40	413
Mixed dishes	2	53	264
Sweets	1	22	92
Supplements	1	3	5
Snacks/other	1	10	93
Total (mg/day)	189	493	1,642

[a]Calculated as the product of the mean intake of sodium by 4- to 5-, 6- to 11-, and 12- to 24-month-old infants and toddlers (Tables 1-3) and the percentage of total sodium and potassium intakes contributed at each age by each food group (Table 4).

Tables 6 and 7 also show the contributions of the different food sources to the mean sodium and potassium intakes, respectively, of 4- to 5-, 6- to 11-, and 12- to 24-month-old infants and toddlers. However, in these tables, the contributions of the different food sources are expressed as mg/day rather than percent of total intakes. Although the percent of sodium and potassium intakes contributed by a specific food group may decrease over time, these tables show that the actual intakes (mg/day)

Table 7. Contribution of different food sources to mean potassium intakes (mg/day) of 4- to 5-, 6- to 11-, and 12- to 24-month-old infants and toddlers[a]

Food group	4-5 Months (n=624)	6-11 Months (n=1,395)	12-24 Months (n=1,003)
Milk	594	587	794
Grain products	51	119	120
Fruits/fruit juices	47	231	414
Vegetables	30	137	177
Meats/other protein	1	43	217
Mixed dishes	4	67	110
Sweets	3	31	83
Supplements	2	4	6
Snacks/other	1	5	47
Total (mg/day)	733	1,224	1,968

[a]Calculated as the product of the mean intake of potassium by 4- to 5-, 6- to 11-, and 12- to 24-month-old infants and toddlers (Tables 1-3) and the percentage of total sodium and potassium intakes contributed at each age by each food group (Table 5).

from that food group may increase, particularly after the first 12 months of life. For example, although the percentage contribution of milk products to total sodium and potassium intakes decreases dramatically from 4 to 5 months of age to 12 to 24 months of age, the actual intakes (mg/day) increase by 34%.

Changes in percent of daily sodium and potassium intakes from different food sources over shorter periods during the first 24 months of life are shown in Tables 8 and 9 (cf., Tables 4 and 5), respectively. Milk, the major source of sodium intake of 4- to 5-month-old infants, accounted for only about a third of the sodium intake of the 9- to 11-month-old infants, about a fourth of the intake of the 12- to 15-month-old infants, and less than 20% of the intake from 15 to 24 months of age. The contributions of grain products, meats and other proteins, mixed dishes, and vegetables to total sodium intake followed an opposite pattern, increasing steadily from an almost negligible percentage of intake at 4 to 5 months of age to a sizeable percentage by 9 to 11 months of age. Fruits and fruit juices were not a major source of sodium intake at any age. Sweets accounted for a very small percentage of the sodium intake of 4- to 5-month-old children, but accounted for 4% to 6% of the total sodium intake of children over 6 months of age. Snacks as a source of sodium intake also increased consistently from a negligible percentage of the total sodium intake of the 4- to 5-month-olds to about 7% of the intake of 19- to 24-month-olds.

The contribution of milk to total potassium intake (Table 9) decreased rapidly from 4 to 5 months of age to 6 to 8 months of age and, then, more gradually through 18 months of age. The contribution of grain products to the total potassium intake was highest during the second 6 months of life, but contributed 6% to 7% of potassium intake at all ages. Fruits and fruit juices accounted for roughly 20% of the total potassium intake of children over 6 months of age and vegetables accounted for a sizeable percentage at all ages. The contribution of meat and other protein to total potassium intake increased from very little at 4 to 5 months of age to about 12% at 19 to 24 months of age. Mixed dishes and sweets contributed very little to the potassium intake of 4- to 5-month-olds, but each food group contributed about 5% of the total potassium intake between 19 and 24 months of age. Other foods contributed minimally to the total potassium intake during this period.

Tables 10 and 11 show the contribution of different milk products to the mean sodium and potassium intakes, respectively, of 4- to 5-month-old, 6- to 11-month-old, and 12- to 24-month-old infants and toddlers. A similar breakdown of the contribution of different foods within each major food group was not as interesting as the contribution of various milk products at different ages; hence, these data are not included.

As shown in Table 10, breast milk and infant formulas were the only milk products contributing to the sodium intake of 4- to 5-month-old, as well as 6- to 11-month-old, infants. However, the percent from breast milk was ~50% lower at 6 to 11 months than at 4 to 5 months and the percent from formula was 23% higher. After 12 months of age, breast milk and formula accounted for very little of the sodium intake from milk products. Of the 90% of sodium intake from cow's milk at this age, about 25% was from reduced-fat milk.

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

Breast milk and infant formulas were the only milk products contributing to the sodium intake of 4- to 5-month-old, as well as 6- to 11-month-old, infants.

For the most part, contributions of different milk products to total sodium and potassium intakes of infants and toddlers reflect current feeding advice (14,15). An exception concerns the contribution from breast milk, which is lower than desired, particularly for the youngest group. Of particular note is the fact that cow's milk did not account for a significant intake of sodium and potassium until after 12 months of age and that about 25% of cow's milk intake was low-fat milk, rather than whole milk as usually advised (14,15).

DISCUSSION

Data reported here show that the usual mean sodium (and chloride) intakes of 4- to 5-month-old, 6- to 11-month-old, and 12- to 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%. Moreover, the usual mean intakes of these

Table 8. Changes in percent of daily sodium intake from different food sources over the first 24 months of life

Food source	4-5 Months (n=624)	6-8 Months (n=708)	9-11 Months (n=687)	12-14 Months (n=371)	15-18 Months (n=312)	19-24 Months (n=320)
Milk	92.2	66.1	36.0	24.3	18.8	16.0
Grain products	2.6	9.2	18.8	20.1	19.6	21.0
Fruits	0.3	1.3	0.9	0.3	0.3	0.2
Fruit juices	0.5	1.0	0.8	0.4	0.4	0.3
Vegetables	2.0	6.8	7.0	6.4	8.3	7.0
Meats/other protein	0.1	3.0	13.4	21.4	23.8	28.3
Mixed dishes	1.0	7.1	14.6	17.6	17.1	14.4
Sweets	0.3	3.6	5.4	5.1	5.8	5.8
Supplements	0.6	0.6	0.6	0.2	0.6	0.2
Snacks/other	0.5	1.3	2.6	4.1	5.3	6.8

Table 9. Changes in percent of daily potassium intake from different food sources over the first 24 months of life

Food source	4-5 Months (n=624)	6-8 Months (n=708)	9-11 Months (n=687)	12-14 Months (n=371)	15-18 Months (n=312)	19-24 Months (n=320)
Milk	81.3	52.0	43.7	45.3	40.6	37.5
Grain products	7.0	10.0	9.5	6.5	6.1	5.9
Fruits	4.5	12.8	13.3	11.7	10.5	10.9
Fruit juices	1.9	4.9	6.9	7.4	10.1	11.6
Vegetables	4.1	12.0	10.4	8.2	9.3	9.2
Meats/other protein	0.1	1.4	5.7	8.7	10.7	12.4
Mixed dishes	0.6	4.4	6.6	7.0	5.8	4.6
Sweets	0.4	1.9	3.1	3.9	3.6	4.8
Supplements	0.2	0.3	0.3	0.1	0.7	0.2
Snacks/other	0.1	0.6	0.6	1.2	2.5	3.0

Table 10. Contribution of different milk products to mean sodium intakes (mg/day) of 4- to 5-, 6- to 11-, and 12- to 24-month-old infants and toddlers

Milk product	4-5 Months (n=624)	6-11 Months (n=1,395)	12-24 Months (n=1,003)
Total	173	186	310
Breast milk	66	36	12
Infant formula	107	141	16
Cow's milk	0	9	279
Whole	—	7	203
Low-fat	—	2	75
Soy milk	0	0	3

Table 11. Contribution of different milk products to mean potassium intakes (mg/day) of 4- to 5-, 6- to 11-, and 12- to 24-month-old infants and toddlers

Milk product	4-5 Months (n=624)	6-11 Months (n=1,395)	12-24 Months (n=1,003)
Total	594	587	794
Breast milk	237	107	22
Infant formula	356	432	39
Cow's milk	0	42	712
Whole	—	33	518
Low-fat	—	9	195
Soy milk	0	5	22

nutrients by 12- to 24-month-old toddlers exceeded the UL. Usual mean potassium intakes of the 4- to 5-month-old and 6- to 11-month-old infants also exceeded the AIs of potassium for these age groups (by 75% and 80%, respectively); in contrast, the usual mean potassium intake of 12- to 24-month-old infants was only 66% of the AI of potassium for 1- to 3-year-old children.

Because the sodium contents of human milk and infant formula are similar (~25 mg/100 kcal) and these products contribute 92% of sodium intake of 4- to 5-month-olds and 51% of the sodium intake of 6- to 11-month-olds, the "high" intakes of sodium suggest that the DRI may be low, the intake of formula and/or breast milk may be excessive, or that the intakes reported may be falsely high. Because exclusively breastfed infants under 6 months of age, the basis of the DRI of 4- to 5-month-old infants, seem to do quite well, it is unlikely that the DRI of this group is low. Availability of weight data would help in determining which of the other two 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 the same infants were 10%, 23%, and 31% higher, respectively, than the estimated energy requirement of 0- to

6-month-old and 7- to 12-month-old infants as well as 1- to 3-year-old toddlers (8), supporting the likelihood of excessive breast milk and/or formula intake. However, overreporting intakes by parents of young infants and children is a recognized problem.

Whether the usual mean sodium, chloride, and potassium intakes of infants and toddlers should be a concern is not clear. The sodium (and chloride) intakes of the 4- to 5-month-old and 6- to 11-month-old infants differ little from the intakes of these nutrients reported for these age groups approximately 20 years ago (9), which was after infant formula and complementary food manufacturers had voluntarily reduced the sodium content of their products.

Nonetheless, the usual mean sodium and chloride intakes of 4- to 5-month-old and 6- to 11-month-old infants exceeded the AI by 60% and 33%, respectively, and the usual mean sodium intake of 12- to 24-month-old toddlers exceeded the UL of this age group by about 10%. Usual mean potassium intakes of 4- to 5-month-old and 6- to 11-month-old infants also exceeded the AIs (by 82.5% and 75%, respectively), but the usual mean intake of 12- to 24-month-old toddlers was only 66% of the DRI of potassium for this age group. The major concern with a high sodium intake is that it may contribute to development of hypertension, but there is no conclusive evidence that this is a major concern in childhood. Studies in adults show a continuous increase in blood pressure with increasing sodium intake, starting at quite low intakes (16). Another concern, for which there is even less data, is that high sodium intakes in infancy may enhance the likelihood of hypertension in adulthood.

Plasma concentrations of both sodium and potassium are maintained within very narrow limits. Thus, unless losses (eg, excessive sweating, diarrhea, and/or vomiting) or intakes are excessive, plasma concentrations of both remain within these very narrow limits. However, this exquisite control under usual circumstances does not indicate that intakes should not be a concern. Certainly, intakes close to recommended intakes 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 problematic, it is important to note that the median sodium intake of 6- to 11-month-old infants is very close to the AI. Thus, the current sodium intake of most 6- to 11-month-old infants is unlikely to be a major problem. The relatively small sample size of 4- to 5-month-old infants and the fact that the intake data were not normally distributed prevented calculation of the usual median intake and usual intake percentiles of this age group. Moreover, the Food and Nutrition Board did not set ULs for 0- to 6-month-old infants. Thus, it is difficult to assess the mean sodium and potassium intakes of this group, which are 57% and 83% higher, respectively, than the AIs. At any rate, as noted above, unless the human milk and/or formula intakes of this age group were excessive relative to the intakes from 780 mg/day of human milk (or formula, which has roughly the same concentrations of sodium and potassium as human milk) used in determining the AI, there is little that can be done other than to advise a lower intake of breast milk and/or formula. However, such advice is not warranted until more is known about the actual breast milk and formula intakes of this age group.

Because even the 10th percentile of usual sodium intake by 12- to 24-month-old toddlers is somewhat higher than the UL 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. Further, the usual mean intake of potassium by this group is less than the DRI (AI) of potassium, suggesting some level of inadequacy of potassium intake by this group. Regardless of whether the high sodium and low potassium intakes of toddlers are problematic, efforts to bring intakes closer to AIs seem warranted. A review of the food sources of sodium and potassium intakes at various ages (see Tables 4-11) provides some clues for how to accomplish this.

The bulk of the sodium and potassium intakes of 4- to 5-month-old infants comes from human milk and formula, which have roughly the same sodium concentrations. Thus, as noted above, the only way to lower the sodium and potassium intake of this group is to limit intake. Because formula has a higher potassium content than human milk, increasing the prevalence of breastfeeding, as universally recommended (15,16), will decrease potassium intake to some extent.

The major concern with a high sodium intake is that it may contribute to development of hypertension, but there is no conclusive evidence that this is a major concern in childhood.

Foods other than milk contribute to the sodium and potassium intakes of 6- to 11-month-old infants and 12- to 24-month-old toddlers. Because concentrations of both sodium and potassium are 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 but will not increase potassium intake appreciably. For example, a 1-oz serving of commercially prepared infant turkey provides 13 mg sodium and 45 mg potassium, whereas a 1-oz serving of processed turkey breast luncheon meat provides 335 mg sodium and 39 mg potassium. Other processed meats (eg, 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 and vegetables also are low in sodium and high in potassium. So, increasing intake of fruits and vegetables by children over 1 year of age, as frequently advocated, will provide potassium without excessive sodium.

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's

milk. Introduction of table foods usually begins at about 9 months of age and by 12 months of age most children are eating table food almost exclusively (see Tables 8 and 9). Because the sodium concentration of cow's milk (80 mg/100 kcal) is more than threefold higher than the sodium concentration of human milk and formula, transition from human milk or formula to cow's milk also results in a marked increase in sodium intake. The major drawback to delaying introduction of cow's milk and continuing formula well into the second year of life is the much higher cost of formula. Thus, considering the limited evidence that current sodium intake of most toddlers is problematical, one is reluctant to advise continuation of formula beyond about 12 months of age. Delaying introduction of table foods is also questionable. These foods not only provide nutrients but also serve an important developmental role. On the other hand, because 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. 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. Obviously, the intake of salty snacks should be limited.

Although the sodium intake of infants and toddlers decreased dramatically during the mid-1970s (9), there seems to have been little additional change since. Some simple ways of decreasing sodium intake of all infant and toddlers and increasing the potassium intake of toddlers are suggested. Despite the limited evidence that current intakes are problematical, implementing these suggestions seems reasonable.

CONCLUSIONS

Whether the current, somewhat high sodium intake of infants and toddlers, particularly toddlers, and the somewhat low potassium intake of toddlers are problematical is not clear. Nonetheless, it seems desirable to bring intakes closer to AIs. This can be accomplished by:

- continuing breast- or formula-feeding and delaying introduction of cow's milk;
- limiting the amount of table salt added to home-prepared foods;
- encouraging intake of fruits (which have a high content of potassium relative to sodium) and vegetables;
- using whole grain cereals and other grain products, which are higher in potassium than highly processed grains; and
- limiting intake of foods with high sodium content (eg, processed meats and salty snacks).

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