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Original Article

Salt Toxicity (Sodium Intake): A Serious Threat to Infants and Children of Pakistan

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Abstract

Background: Excess sodium intake can lead to hypertension, the primary risk factor for cardiovascular disease. The aim of this study was to investigate the sodium and potassium contents of foodstuff used by infants and children of Pakistan.

Methods: We analyzed the sodium and potassium contents of infant milk formula (<6 months), follow up milk formula (>6 months), baby food (cereals), biscuits, fruit juices, potato chips (crisps), cheese puffs, roasted cereals (salty), ice cream cones (*kulfi*) all of which are the processed food extensively used by the children. The amount of sodium and potassium contents in drinking water of few cities of Pakistan were also considered to assess the additional sodium/potassium in the preparation of milk using infant milk formula.

Results: Na to K ratio (Na:K) was determined 0.3-1.23, 0.3-1.16, 0.33-0.82, 0.54-2.68, 0.51-0.85, 2.86 and 1.02 for infant milk formula (<6 months), follow up milk formula (>6 months), baby food (cereals), biscuits, fruit juices, potato chips (crisps, cheese puffs, roasted cereals), ice cream cones (*kulfi*), respectively.

Conclusion: The higher sodium content is present than most of the quoted values; whereas lower potassium is present than the recommended values. The higher Na:K ratio indicates the severity of the situation where it is commonly stated that "higher an individual's salt intake, the higher an individual's blood pressure". Present study indicates that nearly all Pakistani children consume substantially more salt than they need which will affect health status in later life.

Keywords: Dietary intake, Infant milk formula, Na/K ratio, Hypertension

Introduction

Infancy (Babyhood) is defined as the period from birth to 12 months; this is a critical period for young children and dietary habits during this period will affect health status in later life. During infancy, the small child is in a state of transition, adapting from intrauterine to extra-uterine nutrition (1). Infant is breast-fed in early months of life and is supplied with all the nourishment it needs to survive (2). However; if the mother's milk is not available due to some reasons, milk substitutes and complementary feeds are introduced. In such practices, there is a rise in dietary sodium consumption (3). Sodium intake should vigilantly be monitored in infants since their excretory system eliminate sodium with less efficiency than that of adults (4). Consequently, excess sodium may result in immediate health implications for the young infant, as well as affecting their long-term health status. Children are likely to maintain their dietary intake patterns from childhood into adolescence. Therefore children with high sodium intakes are likely to consume higher amount of salt in later ages, which cause more than 20 salt-related health problems, most like the hypertension and cardiovascular disease (5). In a study conducted by Hofman et al., (6) in which infants were randomized to low or normal sodium diet (formulae milk and feeds) for the first 6 months of life. A 15-year follow-up of 35% of the participants found that mean blood pressure (systolic and diastolic) were noticeably lower among the group originally randomized to the low-salt diet compared with the high-salt group. Other studies have investigated habitual sodium intakes during infancy in detail (3-19). Recommended Daily Nutrient Intakes (RNI) of potassium for children 1 to 3 years of age is 3,000 mg/day, 4 to 8 years of age is 3,800 mg/day, and 9 to 13 years of age is 4,500 mg/day (15).

The prevalence of hypertension in Pakistan is one of the highest in the world, and the Pashtun communities, compared to other South Asian ethnic subgroups, are particularly predisposed to this condition. In the first population-based report on the burden of stroke in a community in Pakistan reports one in two persons aged 40 years or over belonging to the Pashtun ethnic group suffer from hypertension. Systolic blood pressure, diabetes, and increased dietary salt intake were identified as independently associated with stroke in this high-risk population (20).

No any reports available regarding dietary sources and Na/K correlates from Pakistan, or the Na/K intake by the infants. The present study deals with identification of few dietary sources for infants and children. Major problem of identifying the common dietary sources were the proper labeling of the local products, i.e. the exact amount of nutrient or Na/K in the given dietary sources as it is important to read the food label and determine the sodium content.

In present study we analyzed the sodium and potassium contents of infant milk formula (<6 months), follow up milk formula (>6 months), baby food (cereals), biscuits, fruit juices, potato chips (crisps), cheese puffs, roasted cereals (salty), ice cream cones (*kulfi*) all of which are the processed food extensively used by the children. The amount of sodium and potassium contents in drinking water of few cities of Pakistan were also considered to assess the additional sodium/potassium in the preparation of milk using infant milk formula.

Materials and Methods

Infants and children's eating habits mainly rely on the demographic situation, however, in infancy the child is only dependent on the mothers or formula milk/cow's milk. We selected infant milk formula (<6 months, Stage I), follow up milk formula (>6 months, Stage II), baby food (cereals), biscuits, fruit juices, potato chips, cheese puffs, roasted cereals (salty), and ice cream cones based on the fact that most of these items are generally given to the children other than the home-cooked items. Furthermore, these items are available at the door steps as it is a common practice to sell things on wooden carts by roaming in streets. Ten each of different samples of milk products; infant milk formula (<6 months), follow up milk formula (>6 months), baby food (cereals), twenty each of biscuits, fruit juices, potato chips, cheese puffs, roasted cereals (salty), and ice cream cones (local word *kulfi*), samples etc, covering different products and a wide range of Na, K contents were collected from local market. The overall principle of the method taken as applicable for all the samples, i.e. the organic matter was decomposed by wet digestion using nitric acid. Ash was dissolved in a nitric acid solution, and wet digests were diluted with water. Test and calibration solutions were atomized into an air–acetylene flame of an atomic absorption spectrometer and the absorption of the elements was measured at appropriate wavelengths.

Ashed samples were dissolved in 1 mL of nitric acid solution. The crucible content was transferred quantitatively into a 250 mL one-mark volumetric flask and made up to volume with water, then mixed thoroughly. Wet digests were cooled to room temperature while reducing to atmospheric pressure before quantitative transfer into 50 mL volumetric flasks, made up to volume with water, then mixed thoroughly. According to the type of test sample and the element measured, the test solution was diluted, and a volume fraction of 10% (one-tenth of the measuring flask volume) of lanthanum trichloride solution was added to suppress phosphate interference and the ionization of elements in the FAAS. A blank test using the same procedure was carried out in parallel with the procedure for the test portion. Analytical grade reagents were used, and a standard working solution of 100 mg/L Na and K was prepared from the respective chlorides (weights refer to the cations).

Perkins Elmer AAnalyst 700 atomic absorption spectrophotometer was used to conduct the study. The wavelength of the spectrometer was set at 589 nm for Na, 766.5 nm for K as given in method protocol by Perkins Elmer, using single element hollow cathode lamps for Na and K. The volumes and corresponding concentrations of samples were selected within the linear range of the particular instrument used (at least five concentrations). The mean of the absorbance values was calculated and the mean of the absorbance value of the zero solution subtracted. For each test solution, the measurement was repeated three times, the average of the absorbance values was calculated and the mean absorbance value of the blank was subtracted.

Statistics

In all cases, analysis of the data was carried out by applying one-way ANOVA with a probability of $P<0.05$ set as statistically significant.

Results

Infant milk formula (powdered) and milk formula (>6 months) of different brands were analyzed for sodium and potassium contents. The determined concentrations of sodium and potassium were significantly ($P<0.05$) higher than the manufacturer quoted values for sodium and significantly ($P<0.05$) lower than quoted value of potassium. The Na to K ratio calculated from quoted values lies in the range of 0.25-0.47 which is well below 1. However, this ratio is significantly ($P<0.05$) higher in actual experimental determined values of Na & K, i.e. 0.3-1.23 (Table 1 & 2). The concentration of Na & K in baby cereals is presented in Table 3). Significantly ($P<0.05$) higher concentration of sodium was observed in biscuits (sweet and saltish) ranging from 240-1123 mg/100 g, most of the manufacturer does not quote sodium or potassium contents (unpacked biscuits are also being in use). The results are presented in Table 4.

In fruit juices (ready to drink for all ages), sodium benzoate (E211) is commonly used as preservative in fruit juices and sodium citrate is used to control acidity in fruit juices, Sodium caseinate (E469) used as thickener and binder, all of which results in increase of sodium other than the added salt. Most the manufacturer does not provide any information regarding sodium or potassium contents in Pakistan. However the imported juices show only sodium contents. We have selected the sour or acidic taste juices for our study. The Na:K ratio was found to be in the range of 0.51-0.85 (mean 0.72). Most of the juices samples were found to contain more sodium than the quoted value, whereas potassium was present lower than the recommended value.

Labeling of sodium or potassium in nutrient panel is missing in most of the cases, or just sodium is quoted as (0.1g/10 g). The analyzed sodium content is significantly ($P<0.05$) higher than the quoted values in the range of 1072-2689 (mean 1750) mg/100 g, whereas potassium is present in the range of 501-750 (mean 612) mg/100 g. The mean Na:K ratio is quite high, i.e. 2.86.

The concentration found for sodium and potassium vary sample to sample and is in the range of 1150-2910 mg/100 g (mean 1952 mg/100 g) whereas potassium is 534-858 mg/100 g (mean 712 mg/100 g). The mean Na:K ratio is quite high i.e. 2.74 (Fig 1).

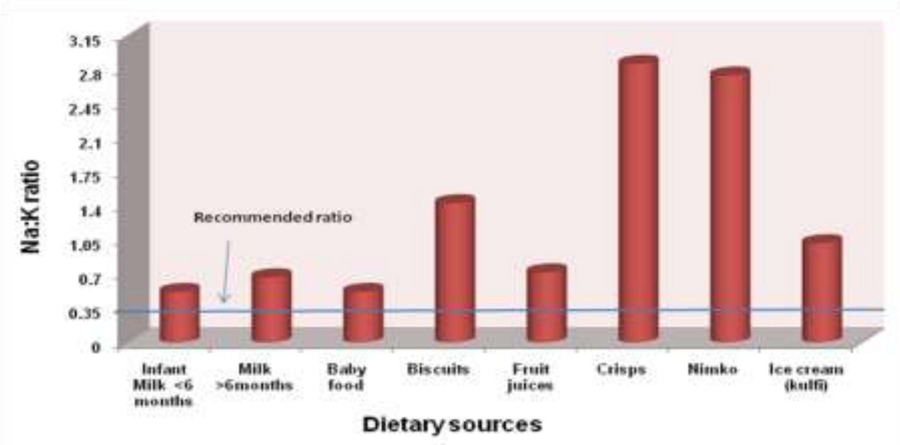

Fig. 1: Ratio of various dietary sources for infant and children

The sodium content of the analyzed samples ranged between 413-815 mg/100g (mean 612 mg/100 g). This high value may come from the milk original sodium content, sodium preservatives and thickening agents. In addition to the original sodium content the increase in sodium occurs during removing of ice cream cone (*kulfi*) from conical mould which is kept in ice cold brine (concentrated NaCl solution) in container. The mean Na:K ratio found was found to be 1.02.

Table 1: Determination of sodium and potassium in milk samples of stage I

Sample No.	Concentrations (mg/100 g) Quoted value (Na)	Calculated value (Na)	Quoted value (K)	Calculated value (K)	Na/K ratio Quoted	Calculated
ST-I1	145	196**	450	430**	0.32	0.46**
ST-I2	130	225**	485	480*	0.27	0.47**
ST-I3	160	172**	540	570**	0.30	0.30*
ST-I4	126	174**	512	480**	0.25	0.36**
ST-I5	165	180**	350	330**	0.47	0.55**
ST-I6	160	187**	420	410*	0.38	0.46**
ST-I7	145	185**	350	150**	0.41	1.23**
ST-I8	269	280**	605	601*	0.44	0.47*
ST-I9	207	253**	507	459**	0.41	0.55**
ST-I10	180	212**	600	560**	0.30	0.38**

Note: ** indicates significant difference, while * indicates non-significant difference.

Table 2: Determination of sodium and potassium in milk samples of stage II

Sample No.	Concentration (mg/100 g) Quoted value (Na)	Calculated value (Na)	Quoted value (K)	Calculated value (K)	Na:K ratio Quoted	Calculated
ST-III01	222	198**	866	556**	0.26	0.36**
ST-III02	212	245**	811	816*	0.26	0.30**
ST-III03	170	186**	629	521**	0.27	0.36**
ST-III04	210	298**	625	579**	0.34	0.51**
ST-III05	195	211**	758	538**	0.26	0.39**
ST-III06	220	294**	642	567**	0.34	0.52**
ST-III07	NA	479	NA	357	-	1.34
ST-III08	NA	452	NA	258	-	1.75
ST-III09	NA	391	NA	262	-	1.49
ST-III10	NA	365	NA	287	-	1.27

Note: ** indicates significant difference, while * indicates non-significant difference.

Table 3: Determination of sodium and potassium in baby food

Sample No.	Concentration (mg/100 g) Quoted value (Na)	Calculated value (Na)	Quoted value (K)	Calculated value (K)	Na:K ratio Quoted	Calculated
BC-1	220	215*	670	651**	0.33	0.33*
BC-2	232	252**	738	553**	0.31	0.46**
BC-3	216	285**	625	534**	0.35	0.53**
BC-4	198	182**	590	514**	0.34	0.35*
BC-5	211	345**	780	495**	0.27	0.70**
BC-6	195	218**	765	454**	0.25	0.48**
BC-7	198	218**	640	355**	0.31	0.61**
BC-8	220	222*	610	680**	0.36	0.33*
BC-9	245	314**	480	510**	0.51	0.62**
BC-10	210	412**	560	501**	0.38	0.82**

Note: ** indicates significant difference, while * indicates non-significant difference.

Table 4: Determination of sodium and potassium in biscuits

Sample No.	Biscuits (mg/100 g) Reported value (Na)	Calculated value (Na)	Reported value (K)	Calculated value (K)	Na:K ratio
BS1	350	410**	NA	252	1.63
BS2	350	390**	NA	357	1.09
BS3	240	394**	NA	356	1.11
BS4	110	240**	NA	412	0.58
BS5	368	520**	NA	194	2.68
BS6	330	421**	NA	252	1.67
BS7	340	367**	NA	357	1.03
BS8	230	314**	NA	433	0.73
BS9	130	230**	NA	423	0.54
BS10	318	510**	NA	431	1.18
BS11 (salted)	513	810**	NA	453	1.79
BS12 (salted)	750	865**	NA	675	1.28
BS13 (salted)	NA	989	NA	675	1.47
BS14 (salted)	NA	1123	NA	765	1.47
BS15 (salted)	NA	902	NA	512	1.76
BS16 (salted)	NA	1031	NA	534	1.93
BS17 (salted)	NA	1321	NA	564	2.34
BS18 (salted)	NA	946	NA	589	1.61
BS19 (salted)	NA	850	NA	665	1.28
BS20 (salted)	NA	912	NA	654	1.39

Note: ** indicates significant difference, while * indicates non-significant difference.

Discussion

The aforementioned literature review provides sufficient evidence for correlating high sodium and low potassium in diet with hypertension. Correlation of sodium with dietary sources can provide guideline to limit sodium intake for infants, children and adults. On average, the natural salt content of food accounts for only about 10 percent of total intake, while discretionary salt use (i.e., salt added at the table or while cooking) provides another 5 to 10 percent of total intake. Approximately 75 percent is derived from salt added by manufacturers (21).

Sodium is found in most foods as sodium chloride, generally known as 'salt'. It is also present in the diet as sodium bicarbonate and as monosodium glutamate in processed foods. Sodium is also present in other food additives such as sodium phosphate, sodium carbonate and sodium benzoate, sodium citrate, sodium casienate (21). One gram of sodium chloride contains 390 mg (17 mmol) of sodium. During infancy the initial source of dietary sodium is milk (human or formula). The human breast milk is considered to be the best diet for infants providing all the nutrients required by the infants. The average concentration of sodium and potassium is 160 & 500 mg/L (7 & 13 mmol) in breast milk respectively. Adequate intake (AI) of sodium and potassium is 120 & 400 mg/L (5.2 & 10 mmol) as of 0.78 L/day consumption of breast milk (22).

Although cow's milk-based infant formulae contains more sodium than human milk; the sodium concentration is dependent on the water source used to dilute it. Once table foods are introduced (about seven months of age), the sodium content of an infant's diet increases rapidly (3). The regulation for infant milk formulae in Europe supports an intake of 127-292.5mg Na/d (mean 204) & 360-756 (mean 558) mg K/d (Na:K ratio of 0.36 from mean values). Mineral quantities have been calculated and incorporated into baby formula by the manufacturers in accordance with current directives (23). Figure 1 indicates the Na:K ratio of infant and children dietary sources which clearly indicates that the intake ratio is quite higher from the recommended value of 0.36.

The ratio of Na & K for infant milk formula was found to be 0.3-1.23 (Table 1). This ratio drastically increases as the powder milk is prepared using water of the domestic water supply. The average Na and K concentration varies with the place to place; however, we found the average concentration of Na & K of few cities of Pakistan (24-26). The sodium concentration was observed in the range of 85-143 mg/L and potassium 3-9 mg/L and another study show 243 mg/L of sodium in southern Sindh province, Pakistan (27). If we consider the lower value of 85 mg/L of sodium and higher value of 9 mg/L of potassium, the ratio of sodium to potassium in water will be 9.4. Adding such water to make up the infant formula results in increase of Na:K ratio. In all cases the milk prepared will have Na:K ratio greater than the recommended ratio of 0.36 (Fig. 1). In such cases hypernatremic dehydration may occur due to high sodium contents or concentrate infant formula (28).

Sodium and potassium contents of infant milk formula (<6 months), follow up milk formula (>6 months), baby food (cereals), biscuits, fruit juices, potato chips (crisps), cheese puffs, roasted cereals (salty), ice cream cones (*kulfi*) analysed has been shown to contain more Na and less K as recommended. The amount of sodium and potassium in drinking water was also considered to assess the additional sodium/potassium in the preparation of milk using infant milk formula. Higher Na:K ratio has been observed in all dietary sources for infants and children than the recommended ratio of 0.36 which based on the infant formula regulations for Na and K contents. Mean Na intake largely exceeded, whereas mean K intake was well below, than recommended. As can be seen from the Tables (1-4), that there is discordance between the value reported (if any) and the value calculated (analyzed), this may be due to the reason that the local manufacturer consider salt or sodium related preservative as a harmless flavoring agent or food preservative. In addition, the water used for the manufacturing process is not processed for mineral contents, which adds further Na. Sodium salt is cheaper than the potassium salt for eg, it costs around 5-30 cents approx (USD) for a kilogram of salt (NaCl) and approximately 1-2 US dollars/kg for salt rich in potassium (60% low sodium salt). Due to lower health status in Pakistan, hypertension is not considered as a serious disease and therefore ignored by the majority of population.

Limitation of study

This study only focused on the few food items commonly used in Pakistan by the children's, however, home cooked items also contains added salt which was not included due to the large bias in racial and ethnic differences among the population. A further detailed study/survey is required to assess the salt toxicity and to identify the food dietary sources to curb the causes of hypertension or other diseases in children's and adult population.

Conclusion

It is dire need to control Na and increase K in dietary food for infants and children by promoting the consumption of food categories with a low Na/K ratio such as fruits, vegetables and dairy products for general population.

Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors. The study protocol was approved by the Kashan University of Medical Sciences ethical committee.

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