



Health consequences and biomonitoring of sodium and caffeine intake in children and adolescents

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Key words

Children, sodium, salt, caffeine, blood pressure, biomonitoring

Aims of the study

Part 1: To assess the association between sodium intake and blood pressure in children through a systematic review

Part 2: To evaluate methods, including urine biomonitoring, to measure sodium and caffeine intake in children and adolescents

Material and methods

Part 1: Studies investigating the association between sodium intake and blood pressure in children were identified through a systematic search of the Medline, Embase, CINAHL and CENTRAL databases up to March 2017 and supplemented by a manual search of bibliographies and unpublished studies. Experimental and observational studies involving children or adolescents between 0 and 18 years of age were included. The quality of the sodium intake and BP measurements methods was assessed. Random effects meta-analyses were performed by pooling data across studies. Subgroup and sensitivity analyses were performed. Publication bias was evaluated.

Part 2: A cross-sectional study was conducted in Valais, Switzerland, between September 2016 and February 2018. Children between 6 and 16 years of age visiting several regional health care providers and without any clinical condition that could affect sodium intake or excretion were invited to participate. Each participant collected one 24-h urine sample, three timed urinary spots, i.e., evening, overnight, and morning, and completed two semi-quantitative food frequency questionnaires. The urinary excretions in sodium, creatinine, potassium, caffeine, paraxanthine, theophylline, and theobromine were measured. Eight existing equations to estimate 24-h urinary sodium excretion from spots were tested. The estimates from the different spots and equations were compared with the measured 24-h excretion using several statistics. Caffeine intake was estimated with the questionnaires and compared with urinary excretion in the 24-h urine and spots.

Results and significance

Part 1: Of the 6,861 publications identified, 101 studies (24 experimental and 77 observational) with 61,433 participants were included. Among these studies, only 21 had sodium intake and blood pressure measurements of high quality. In high quality studies among children with normal BP, for every additional gram of sodium intake per day systolic and diastolic BP increased by 0.8 mm Hg (95% CI: 0.4, 1.3) and 0.7 mm Hg (95% CI: 0.0, 1.4), respectively. The association was stronger in overweight children and children with elevated blood pressure.

Part 2: A total of 101 children were recruited. The mean 24-hour salt urinary excretion was 5.9 g. Two thirds of the children had salt excretions above recommendations of maximum intake. The main sources of salt intake were 1) pastas, potatoes, and rice, 2) pastries, 3) bread, and 4) cured meats. One child out of three added salt to their plate at the table. The different spots and equations provided highly heterogeneous estimates of the 24-h urinary sodium excretion. The overnight urinary spots with the equations from Tanaka and Brown provided the most accurate estimates. Based on questionnaire, the mean daily caffeine intake estimate was 36 mg and 1.1

mg/kg. Seven children had a caffeine intake above the upper recommended level of 3 mg/kg per day. The main sources of caffeine intake were 1) tea, 2) cocoa milk, 3) chocolate, 4) soft and energy drink, and 5) mocca yoghurt. Caffeine intake from the questionnaires correlated poorly with urinary excretion of caffeine and its metabolites.

Significance

Part 1: Since blood pressure tracks across the life course, our findings support the reduction of sodium intake during childhood and adolescence, especially in children with elevated BP or overweight, to lower BP and prevent the development of hypertension later in life.

Part 2: Salt intake in children in one region of Switzerland was high. Salt intake in children could be reduced by lowering salt content in commonly eaten foods. Overnight urinary spots with the Tanaka or Brown equation can provide accurate estimates of the 24-h sodium excretion in children. Caffeine intakes in a sample of children in Switzerland was relatively low. The major sources of intake were tea, cocoa milk, and chocolate. Self-reported caffeine intake correlates modestly with 24-h urinary excretion of caffeine and some of its metabolites.

Publications

1. Leyvraz M, Taffé P, Chatelan A, Paradis G, Tabin R, Bovet P, Bochud M, Chiolerio A. Sodium intake and blood pressure in children and adolescents: protocol for a systematic review and meta-analysis. *BMJ Open*. 2016; 6(9):e012518.
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3. Rios-Leyvraz M, Bloetzer C, Chatelan A, Bochud M, Burnier M, Santschi V, Paradis G, Tabin R, Bovet P, Chiolerio A. Sodium intake and blood pressure in children with a clinical condition: A systematic review and meta-analysis of experimental and observational studies. *Journal of Clinical Hypertension* 2019; 21(1):118-126.
4. Rios-Leyvraz M, Bovet P, Bochud M, Genin B, Russo M, Rossier MF, Tabin R, Chiolerio A. Estimation of salt intake and excretion in children in one region of Switzerland: a cross-sectional study. *European Journal of Nutrition* 2018. Epub ahead of print.
5. Rios-Leyvraz M, Bovet P, Tabin R, Genin B, Russo M, Rossier MF, Bochud M, Chiolerio A. Urine Spot Samples Can Be Used to Estimate 24-Hour Urinary Sodium Excretion in Children. *Journal of Nutrition* 2018; 148(12):1946-1953.
6. Rios-Leyvraz M, Bochud M, Tabin R, Genin B, Russo M, Eap CB, Bovet P, Chiolerio A. Assessing caffeine intake and urinary excretion in children in a region of Switzerland. In preparation.

Conference abstracts and poster presentations

1. Leyvraz M, Chatelan A, da Costa BR, Taffé P, Paradis G, Tabin R, Bovet P, Bochud M, Chiolerio A. Assessing the association between blood pressure and sodium intake across usual levels of consumption in children: a systematic review of experimental and observational studies. Poster presentation at the Society for Epidemiologic Research, in Seattle, WA, USA, on 20-23 June 2017.
2. Leyvraz M, Bovet P, Bochud M, Genin B, Russo M, Rossier MF, Tabin R, Chiolerio A. Salt intake and excretion in children in one region of Switzerland: A cross-sectional study. Poster presentation at the Swiss Public Health Conference, Neuchâtel, Switzerland, on 7-8 November 2018.
3. Rios-Leyvraz M, Bovet P, Tabin R, Genin B, Russo M, Rossier M, Bochud M, Chiolerio A. Urinary spots in children: a public health surveillance tool to estimate sodium intake? Abstract at the European Journal of Public Health in November 2018.
4. Leyvraz M, Bovet P, Bochud M, Genin B, Russo M, Rossier MF, Tabin R, Chiolerio A. Sodium intake and blood pressure in children and adolescents with normal and elevated blood pressure: A systematic review and meta-analysis. Poster presentation at the Swiss Public Health Conference, Neuchâtel, Switzerland, on 7-8 November 2018.
5. Rios-Leyvraz M, Bochud M, Tabin R, Genin B, Russo M, Eap CB, Bovet P, Chiolerio A. How to monitor caffeine intake in children? A comparison between questionnaire and 24-h urine excretion. Abstract accepted for poster presentation at the Swiss Public Health Conference, Winterthur, Switzerland, on 28-29 August 2019.

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