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Nutritional Epidemiological Tools for Sodium Intake

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Abstract

Dietary sodium is a determinant of blood pressure. Modern diets provide excessive amounts of salt, and in developed and developing countries the intake of processed foods with high salt levels is increasing. In order to establish effective nutrition policy, it is necessary to know the quantity of consumed salt as well as identify the main dietary sources of salt. Different methods are currently in use for estimating dietary sodium intake. The use of 24-hour urinary collection to assess sodium intake is considered the most accurate method but involves considerable burden for participants. The use of the spot urine method has been proposed as an alternative however in not recommended without calibration methodology. Sodium estimates based on dietary surveys include several methods such the 24-hour dietary recall, the food frequency questionnaire, and the diet record, with often under-estimates intake due to under-reporting and difficulties quantifying sodium in concentration discretionary salt and recipes. Food compositions databases and nutritional softwares can be used to assess sodium consumption. More research is necessary to improve nutritional epidemiological tools for sodium intake.

Keywords: Dietary sodium; Nutritional surveys; Urine; Epidemiology

Introduction

Cardio metabolic diseases (metabolic syndrome and diabetes mellitus 2), are associated to cardiovascular risk factors such as dyslipidemia, abdominal obesity, insulin resistance, and high blood pressure or hypertension, which increase the risk of cardiovascular diseases (CVD), with high global prevalence [1].

Hypertension as a risk factor of CVD results from an interaction between genetic susceptibility and environmental factors. Diet, and specifically dietary sodium, is a determinant of blood pressure. The relation between salt and blood pressure has been studied for many decades. Dietary intake of sodium, or salt, is strongly associated with blood pressure due its central role in determining blood volume [2]. Modern diets provide excessive amounts of salt, and in developed and developing countries the intake of processed foods with high salt levels is increasing. The report of a joint WHO/FAO Expert Consultation on *Diet, Nutrition and the Prevention of Chronic Diseases* recommends that sodium intake of adults should be less than 2 g/day (<85 mmol/day) [3]. Therefore, exists several national and international programs to reduce salt intake.

The main implementation strategies for salt reduction are food reformulation with industry engagement, consumer education, pack labelling information related to salt or sodium, interventions in public institution settings and taxes system [4]. In order to establish effective nutrition policy, it is necessary to know the quantity of consumed salt as well as identify the main dietary sources of salt. However, diet is a dynamic phenomenon and it has been necessary to develop different methods to assess sodium intake, both direct and indirect, that may respond to the needs and possibilities of research.

Use of Urine Biomarkers to Assess Sodium Intake

In homeostasis, kidneys handle most of the sodium consumed in a day, and approximately 90-95% of sodium is excreted in the urine within 24 hours. As a consequence, the use of 24-h urine collections for assessing population and individual sodium intake is continued, and it is widely regarded as the gold standard method for assessment of sodium intake. Besides, this method is often used to compare and validate other methods of sodium intake assessment [5].

The method of 24-h urine collection has been used to assess population sodium intake in large population-based studies such as INTERSALT and INTERMAP. INTERMAP study included measurements of dietary sodium intake based on four 24-h dietary recalls and two timed 24-h urine samples from 17 population samples in Japan, China, UK and the U.S. INTERSALT collected standardized data on 24-h urinary excretion of sodium from 52 population samples in 32 countries around the world [6-10].

Validated protocols have been proposed for using 24-h urine collections. The *WHO/PAHO Regional Expert Group for Cardiovascular Disease Prevention through Population-wide Dietary Salt Reduction* have developed a protocol for sodium determination in 24-h urine samples, and also include questions on knowledge, attitudes and behavior towards dietary salt [11]. However, collection of 24-h urine involves considerable burden for participants, which may introduce bias on results. The use of the spot urine (SP) method has been proposed as an alternative. SP have been widely used to assess other nutritional biomarkers such as proteins. Although SP have potential advantages and they are easier to obtain and store than 24-urine collection, is not recommended without calibration study in the specific population of interest [12,13].

Sodium Estimates Based on Dietary Survey

Dietary intake is a complex variable, influenced by intra- and interpersonal variability and other factors such as day of the week, capture methodology and season. The appropriate methodology for diet analysis depends on consumption data characteristics and, in particular, the frequency of intake of the nutrient or food.

Several methods can be used to assess individual food consumption. The 24-hour dietary recall (24 HDR) is designed to capture all food and drinks consumed in a period of 24 hours. The interview is often structured, to help the respondent remember all foods consumed throughout the day. This method is usually used in national surveys. The distribution of single daily intakes may show a strong variation. For this reason it is convenient interviewing a subsample on a different day (ideally on a weekday and one weekend) to calculate the usual intake. A new methodology from 24 HDR is the U.S. Department of Agriculture's (USDA) Automated Multiple-Pass Method (AMPM), which is used in the U.S. National Health and Nutrition Examination Survey (NHANES) and includes five steps to retrieve forgotten foods [14].

The food frequency questionnaire (FFQ) is a dietary assessment tool also used in large epidemiologic studies of diet and health. Participant reports the frequency of consumption and portion size of food and drinks over a defined period of time. The comprehensiveness of the food list is critical in FFQ method. This method is commonly used for risk studies and it is especially able to quantify intake related to long exposition [15]. The diet record (DR) consist in written records of all food and beverages consumed for 7 days, sometimes three days, and their quantities [16]. DR needs to weigh all consumed food and due its expenses and complexity is generally used only for research projects. Some studies about sodium intake have showed that a seven-day DR was a more reliable estimate of intake than the FFQ [17].

Frequent problems in dietary surveys are the analysis and expression of results. Exist several nutritional softwares to estimate sodium intake. For example, GloboDiet, Epic-Soft, PC-Side and NDSR are used to intake estimating in 24 HDR [18-21]. Other softwares, such as Interfood, Diet*Calc and Nutwin, are usually used for FFQ [22-24].

Dietary surveys need the measure of portion sizes and calculate ingredients and quantities in recipes. In case of salt intake, it could be difficult to calculate the loss of sodium in some culinary practices, such as soaking or rinsing. Besides, the under-reporting is common, with the consequent underestimation of sodium intake [25,26]. Despite their limitations, dietary surveys are useful in epidemiological studies based in population, and they can improve their accuracy by exposure biomarker determination, such as urinary sodium, as well as in the INTERMAP study [27].

Critical points to estimate sodium and salt food sources are food composition databases (FCDs). FCDs provides a detailed profile of the nutritional composition of food, and they are required for the assessment of nutrient intake at the individual, regional, national, or international level. The *International Network on Food Data Systems* (INFOODS) is involved in the generation and compilation of data on the composition of foods around the world, with affiliated organizations in all continents [28]. The INFOODS information is available on-line and it is supporting material for nutritional softwares to estimate dietary intake.

FCDs are constructed using direct data, such as chemical analysis through official techniques, or by using compiling data with several quality criteria pre-defined. There is a continuous research effort to improve the quality information on FCDs [29]. However, further consideration should be given the use of retention factors in recipe calculations, information on food supplements, the applicability of retention factors and the continuous updating.

Table 1 summarizes the main methods of assessment dietary salt intake including advantages and disadvantages.

Conclusions

The described different methods to quantify sodium intake are currently in use. The evaluation of the methods must be selected in accordance with the research interest and the profile of subjects and

		Advantages	Disadvantages
24-h urine collection	This method has been considered the clinical gold standard method to assess an individual's dietary sodium intake on the same day.It is often used to compare and validate other methods of sodium intake assessment.It is mostly available in populations with modest sample sizes.	- Reduces miscalculation in sodium measurement due to changes throughout the day, and on different days.It is independent of subject recall.	- To estimate an individual's usual dietary intake, multiple urinary measurements of sodium are needed.24-h urine collection method is not readily conducted in ordinal population groups. Urine collect may be affected due to physical limitations, urinary incontinence, psychiatric problems, or other reasons.
Spot urine	The casual or spot urine collection is increasingly used as a convenient and affordable alternative	- The spot urine specimen is easier for participants but it is not accurate because of the lack of uniform excretion of sodium throughout the day.Spot urine samples are easily collected and stored without potential for under or over collection.This method is relatively easily incorporated into a nutrition surveys.It is able to be collected in a single encounter.	- As samples are collected at unique one time point, they may introduce an important bias due to temporal changes in urine composition and changes in urine sodium excretion related to the meal timing.The correlation between the estimated and the measured value depends on the timing of urine collection.It is not able to estimate an individual's mean sodium intake.It is a poor predictor of 24-h urinary sodium excretion for individual assessment.
24-hour dietary recall (24 HDR)	The 24-hour dietary recall is an interview-survey that asks respondents to recall everything they ate or drank in the previous 24 hours.	- It can be used with most population groups. - It is used to calculate the usual intake.	- Respondents may underreport and/ or underestimate foods or intake amounts. - Recalls need be collected by trained interviewers with a systematic protocol.

Food frequency questionnaire (FFQ)	The FFQ includes a limited list of foods and beverages and responses to indicate how often each item was consumed over a specified period of time.	- It is especially able to quantify intake related to long exposition. - FFQ can capture typical intakes, rather than a single-day of intake.	- In general, FFQ does not include questions about salt added in cooking or at the table. - The selected foods may limiting the consumption detail.
Diet record (DR)	DR is a detailed description of the types and amounts of foods, beverages, and supplements consumed over a specified time period.	- DR is more reliable to estimate intake than the other methods, such as FFQ.	- Requires a high level of knowledge and motivation. - DR may require training about accurate record intakes.

Table 1: Main methods of assessment dietary sodium intake.

their environment.

The application of dietary surveys needs trained personal, validated questionnaires and reliable information on food composition. Despite the limitations the dietetic survey, and depending its characteristics, is a valid method to provide data about dietary and sodium intake and nutritional status, their relationship with recommended intakes and risk analysis.

Although the 24-h urine collection is a noninvasive method, certain factors or conditions may interfere with the accuracy such as the under-collection by forgetting to collect some urine and cold chain losses. In the clinical practice, using second urine sample after waking-up or spot urine samples is recommended to improve the reliability.

Monitoring of population sodium intake is essential for dietary assessment, for nutritional labeling, and for policy development, according the WHO recommendations. The choice of each method depend on the needs of the researches and cardiologists and the patient´s possibilities. More research is necessary to improve nutritional epidemiological tools for sodium intake.

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